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dSPACE MAGAZINE

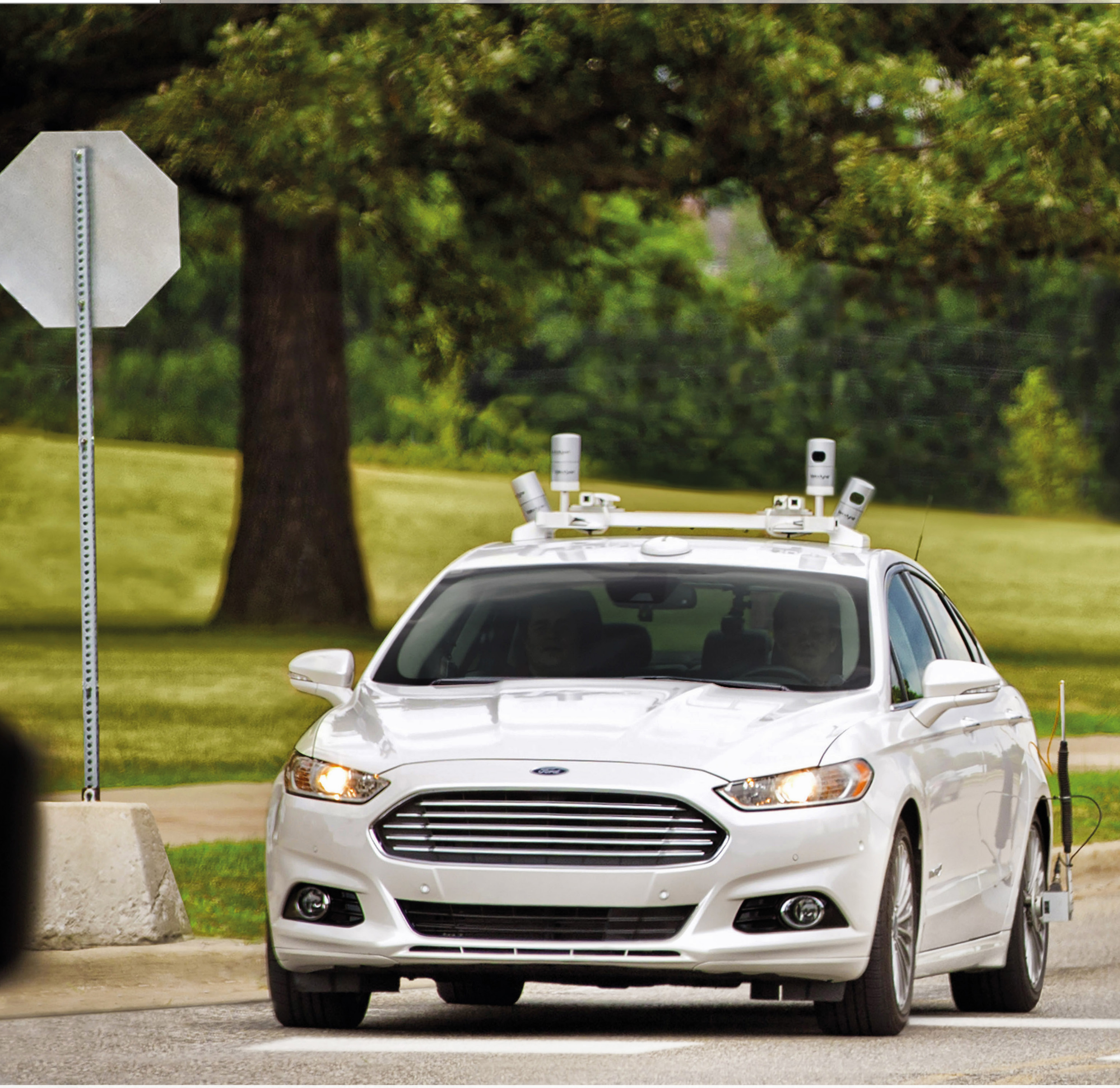
1/2017

Toyota

Efficient Development for Sustainability on the Road | page 12

Jaguar Land Rover – Virtual Validation for Fast Transition to Series Production | page 6

JTEKT – Automated Fault Injection for ISO-26262-Compliant Testing | page 18



"Software for autonomous vehicles is highly complex and requires an immense amount of vehicle testing to achieve a certain level of confidence in safety, quality, and reliability. In order to reduce costs and accelerate autonomous software development, hardware-in-the-loop (HIL) simulation on a dSPACE Simulator is used to supplement vehicle testing."

Adit Joshi, Research Engineer – Automated Driving HIL Simulation, Ford Motor Company

At dSPACE, we do not need creativity workshops. Whenever we have successfully fulfilled a requirement, customers are quick to approach us with new requests. Therefore, new tasks and fields of activity are continuously emerging and we are dedicated to making them a success.

The areas that currently occupy our minds most are driver assistance systems as well as highly automated and autonomous driving. In this magazine, we give you a first introduction to MicroAutoBox Embedded SPU (page 36). Its core task is merging and processing data from multiple sensors. We therefore combine a large number of interfaces and most modern processor architecture with powerful software tooling. Naturally, MicroAutoBox Embedded SPU is also fit for in-vehicle use, as has been the case for our complete MicroAutoBox range for nearly 20 years.

We also address the validation of functions for automated driving that are developed by our customers. Our simulation platform VEOS® lets users perform multiple software tests in parallel and frontload millions of test kilometers for automated driving to the PC to process the complex and diverse test load in an acceptable time. The result is a valuable addition to HIL testing, which saves many iterations and time. The Jaguar Land Rover article demonstrates this vividly and Toyota also reports that a corresponding process is part of their agenda. In both cases, the comprehensive use of the dSPACE tool chain is noteworthy: Safe and efficient development processes are the result.

Also, our company certainly has to invest in our workforce to meet the continuously higher requirements. One factor that makes us especially attractive as an employer is our new day care center that is located very closely to our office. The day care center makes it easy to combine work and family life, and because of its technological and scientific focus, it helps spark the children's interest in the engineer's profession early on. On page 50, you might hence be looking at our technology specialists of tomorrow.

Dr. Herbert Hanselmann

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Implementing virtual validation at Jaguar Land Rover

Virtual Revolution

Jaguar Land Rover's motto is to create "experiences customers love, for life". To achieve this goal and continue to provide quality products to its customers while increasing the number of state-of-the-art features, there is a need for smarter software validation. The answer for Jaguar Land Rover is virtual validation, which is used to achieve the company's goals in early development phases.

The increased demand for technologies with complex software functionality and interaction, such as the autonomy functions provided by some advanced driver assistance features, calls for the introduction of new and improved methods for designing and testing the relevant software. This not only increases the need for testing in general, but also the need for testing new functions as early and efficiently as possible in order to reduce the possibility of errors and thereby mitigate the need for costly late fixes. Being smart about software validation helps Jaguar Land Rover save time and money. Additionally, the number of development, verification and validation (V&V) iterations increases, providing customers with a quality vehicle experience. One of the ways Jaguar Land Rover is being smart is by introducing virtualization, i.e., virtual software verification and validation, in order to detect and eliminate errors earlier, and accelerate the vehicle time to market. In particular, it is useful to take virtual ECUs (V-ECUs) as a means of developing and testing applications in an AUTOSAR software architecture and performing functional verification without the need for the physical target ECU. It lets Jaguar Land Rover perform tests before the supplier has completed an ECU build and provide the supplier with earlier feedback since the developers are able to test in parallel to the supplier activity. >>

Initial Challenges and Solutions

Some of the initial challenges encountered while implementing the virtual validation process in the Power Systems (PS) group included modifying the existing software development process (figure 1) and reconfiguring the tool chain to enable V-ECU development and testing. Various activities were undertaken in order to overcome these challenges. Firstly, a forum was set up to allow different departments to interact more closely. The forum included employees from areas such as software V&V, AUTOSAR architecture, hardware-in-the-loop (HIL) testing, and specific system groups. Together, it was possible to devise two flexible approaches for integrating V-ECU development into the existing software development processes: a bottom-up approach to allow for departments with verified legacy software components (SWCs) to quickly combine them and build an integrated V-ECU, and a top-down approach for those who intend to redesign their V-ECUs for AUTOSAR or other development reasons and for using V-ECUs when developing new features. Both development approaches use the same tool chain (figure 2), and can thus be applied to best suit the needs of the particular feature development project. It is also possible to start development with the bottom-up approach and complete it with the top-down approach, if time permits. Secondly, the forum looked into the use of Functional Mock-up Units (FMUs) for importing existing plant and stimulus models to the VEOS® simulation environment for improved V-ECU testing. It also evaluated dSPACE's Legacy Code Integrator, which generates virtual ECUs from legacy source code, as another tool for building V-ECUs. Lastly, dSPACE employees and HIL test engineers from Jaguar Land Rover looked into tool chain automation for building the V-ECU and setting it up in the test environment. dSPACE was able to customize the workflow by using Python scripts and provided a one-click solution for V-ECU and ControlDesk® plant model creation. The creation of ControlDesk plant models enabled the software engineers at Jaguar Land Rover to reuse the exact same test setup (previously implemented for HIL testing of the physical ECU) for V-ECU testing.

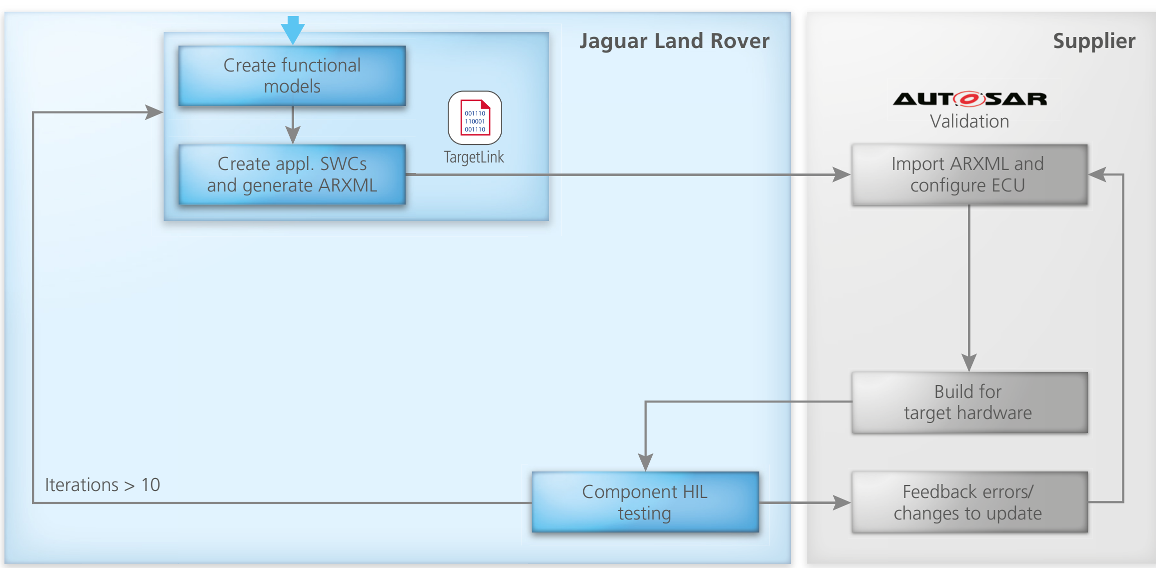
> "Virtual Validation has revolutionized our process."
>
> *Will Suart, Jaguar Land Rover*

Using dSPACE Products

In order to effectively implement the V-ECU development and testing process in the PS group, the following dSPACE tools were used extensively:

1. TargetLink® (Data Dictionary and production code generator), used

Figure 1: Original Power Systems (PS) development process that required multiple costly iterations before the mature application was ready for use.



Appl. SWCs = application software components ARXML = AUTOSAR XML file

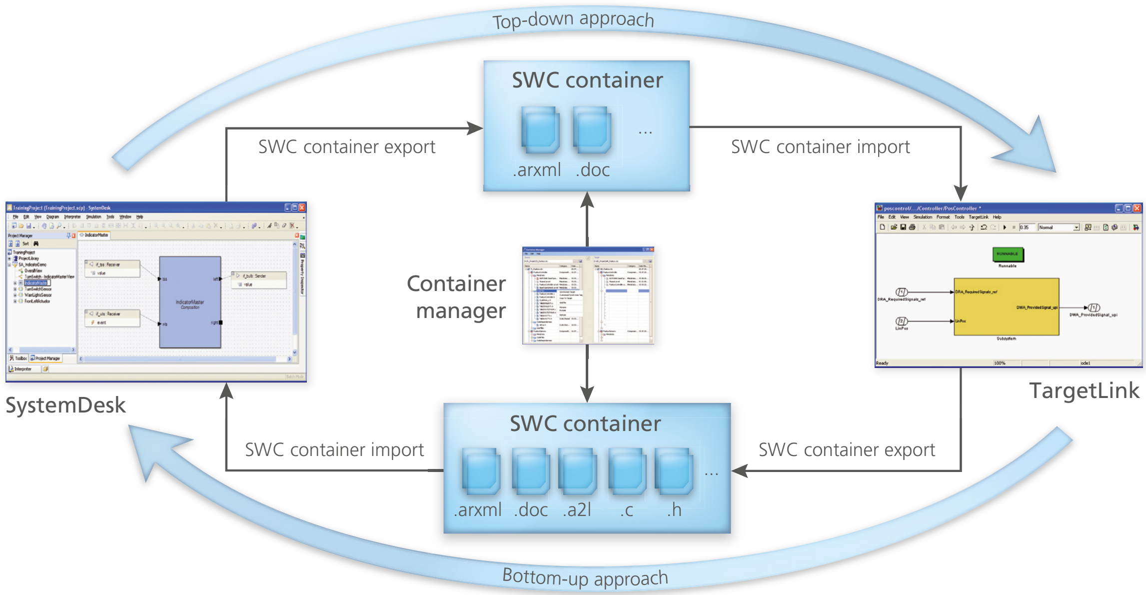


Figure 2: The bottom-up approach, starting the with software components modeled in TargetLink, and the top-down approach, where the architecture is first defined in SystemDesk.

for SWC development and considered a good and industry-standard tool for production code generation.

2. SystemDesk® was introduced to the PS group's tool chain and proved to be a good system architecture tool, used for modeling AUTOSAR architectures, verifying compliance with AUTOSAR rule sets, SWC integration, and V-ECU generation. SystemDesk was not only a new tool for the PS group, but also introduced new activities for the software development team that were previously performed by suppliers. Therefore, it did have a steep learning curve but the documentation is very helpful and it is now an integral tool for these activities.
3. VEOS was another new tool, introduced to simulate the V-ECUs for testing. The flexibility of the simulation platform plays a central role in increasing quality through virtual testing. Key advantages of VEOS are its ability to interact with third-party models and the level of simulation control with functions such as PAUSE, STEP, and setting the execution step time.
4. ControlDesk had already been used as the simulation experiment software by the HIL engineers. The ability to use the same tool and share experiments for testing the V-ECU and real ECU was invaluable from both a time and skills viewpoint.

Overall, dSPACE products played a vital role in implementing the virtual validation workflow at Jaguar Land Rover with the products that were already used for AUTOSAR software development and virtual/HIL testing.

Benefits of Virtual Validation

Virtual validation is used to both frontload testing to earlier phases in the development cycle (left-shift) and to increase the overall quality. Using V-ECUs made it possible to left-shift component-level testing (figure 3). Doing this not only significantly increased the quality and confidence level of the developed software. It also shifted testing to an earlier phase in Jaguar Land Rover's product development cycle. In terms of AUTOSAR component development, the new virtual validation workflow was particularly beneficial in enabling faster roundtrips from the model to the component test platform.
By using the V-ECU development and test process, the PS group was able to save 12 weeks of verification and validation time (figure 4). Additional benefits derived from the virtual validation process include increased error detection capabilities, which in combination with the ability to perform testing earlier, provide an opportunity to perform more extensive HIL testing and robust ECU integration. Increasing the amount and capability of early-stage virtual testing at Jaguar Land Rover, and using the time

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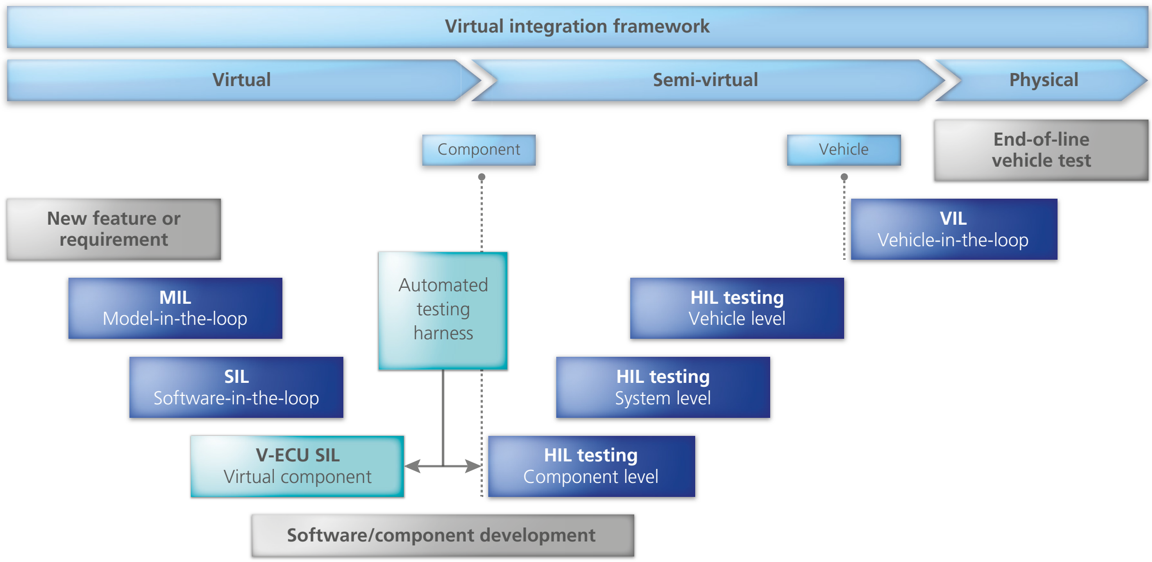


Figure 3: Virtual validation using V-ECUs allows for a left-shift of component testing.

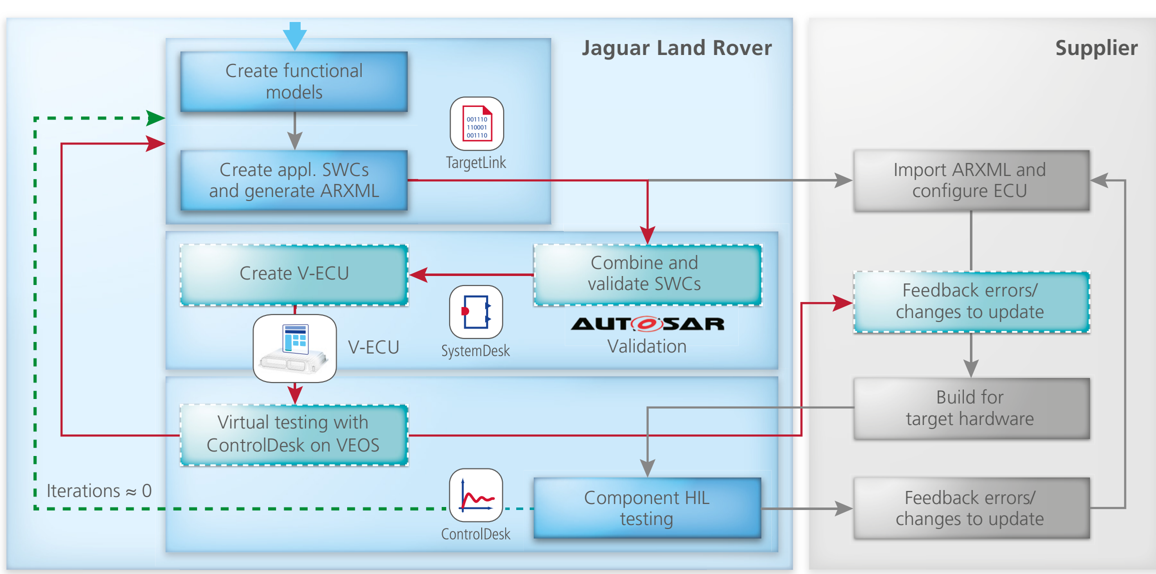
gained to increase robust HIL testing at the component and system levels, provides a visible improvement in quality confidence levels and reduces the overall time to market of the feature software.

The new workflow around the virtual validation process also improved development efficiency, both internally and in the way the Jaguar Land Rover PS group interacts with component suppliers.

Conclusion and Next Steps

Using virtual validation provided Jaguar Land Rover with important insights into changes that need to be implemented in the development process. It also demonstrated the

Figure 4: Modified virtual validation workflow (turquoise boxes and red lines) that increased the testing capability of Jaguar Land Rover. The changes provide increased confidence levels in the correctness of the application before handing it over to the supplier and entail fewer supplier iterations before the product is ready for deployment.



Appl. SWCs = application software components ARXML = AUTOSAR XML file

> "dSPACE products played a vital role in implementing our virtual validation workflow."
>
> *Leonardo Poeti , Jaguar Land Rover*

flexibility of the tool chain and workflow, which can be adjusted to existing processes at Jaguar Land Rover and its suppliers.
Overall, the benefits of implementing virtual validation and supporting a formalized consistent approach to AUTOSAR software development at Jaguar Land Rover are clear.
From now on, Jaguar Land Rover plans to extend its virtual validation capabilities in the following ways:

1. Increase the testing capability by using V-ECUs on SCALEXIO® HIL test rigs and MicroAutoBox® II.
2. Build a network of multiple V-ECUs up to the vehicle representation level in order to perform full-system and vehicle-level virtual validation.
3. Integrate multiple V-ECUs and real ECUs in a HIL simulation environment.
4. Seamlessly migrate from virtual to real ECUs in the V&V environment.
5. Reuse existing system architectures for V-ECU generation when adding new features to an existing ECU. ■

Will Suart,
Leonardo Poeti,
Karthik Ponudurai,
Renjith George,
Jaguar Land Rover

Why Virtual Validation?

- The new virtual validation workflow enabled faster round-trips. In fact, the Power Systems group was able to save 12 weeks of verification and validation time.
- Using V-ECUs made it possible to left-shift component-level testing to a very early stage of Jaguar Land Rover's product development cycle. This left shift significantly increased the quality and confidence level of the developed software.
- dSPACE was able to customize the workflow by using Python scripts and provide a one-click solution for V-ECU creation.
- Jaguar Land Rover was able to reuse the same test setup for V-ECU testing that was previously implemented for HIL testing of a physical ECU.
- The number of costly iterations was reduced from more than 10 to almost 0.
- Up to 80% of ECU testing was performed with V-ECUs

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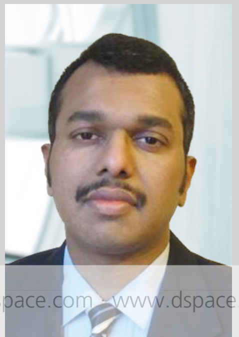


Electrification for sustainable mobility –
Developing the fourth generation of the Toyota Prius

A Forward Leap for E-Volution

The Toyota Prius is internationally known as the pioneer in hybrid technology. To significantly increase not only the vehicle's efficiency but its overall product capabilities, Toyota optimized its entire development process. For this, the company also introduced a new model-based tool chain that includes the production code generator TargetLink from dSPACE and the test solutions of BTC Embedded Systems AG.

How can you maintain mobility without traffic excessively burdening humans and the environment in the long run? This question lies at the core of sustainable mobility, which is a fundamental development goal at Toyota. The new Prius can answer this question. In the JC08 test cycle, its fuel efficiency was improved to 40.8 km/l (95.97 mpg) or 2.45 liters per 100 km. At the same time, the vehicle's drive power was optimized to achieve an even more dynamic driveability.

A Leap Forward in the Evolution of the Prius 4th Generation

The powertrain concept of the vehicle is built on a unique combination of serial and parallel hybrid technology. The basis for this is a planetary gear called power split device (PSD), which connects an internal combustion engine with two electric motors. This allows for purely electric operation, energy recovery as well as serial and parallel operation of the electric motor and the combustion engine. Moreover, the PSD also serves as a continuously variable transmission (CVT). The powertrain is part of Toyota's new modular platform Toyota New Global Architecture (TNGA), which will form the basis of future Lexus and Toyota vehicle models. When the platform was introduced, all involved components were fundamentally re-engineered. This leads to impressive results for fuel consumption. The fuel efficiency of the fourth-generation Prius improved with regard to the country-specific test drive cycles: In Japan, efficiency improved by 26%, in Europe by 20%, and in the US by 14%.

Optimizing Control Development

With the fourth-generation Prius, the control requirements for improving vehicle performance have increased significantly compared to previous generations. Therefore, the optimization of the control structure plays a vital role in increasing development

>>

efficiency. For example, for the 4th generation Prius, motor control had to become highly responsive and capable of high-speed control to reduce the part size and enhance fuel efficiency. To be able to respond quickly to these new types of control requirements, and to be prepared for this and future technical innovations as well as vehicle deployments, Toyota thoroughly evaluated its overall control development. This included the ease of use and efficiency of the control structure, the development process, and the development tools.

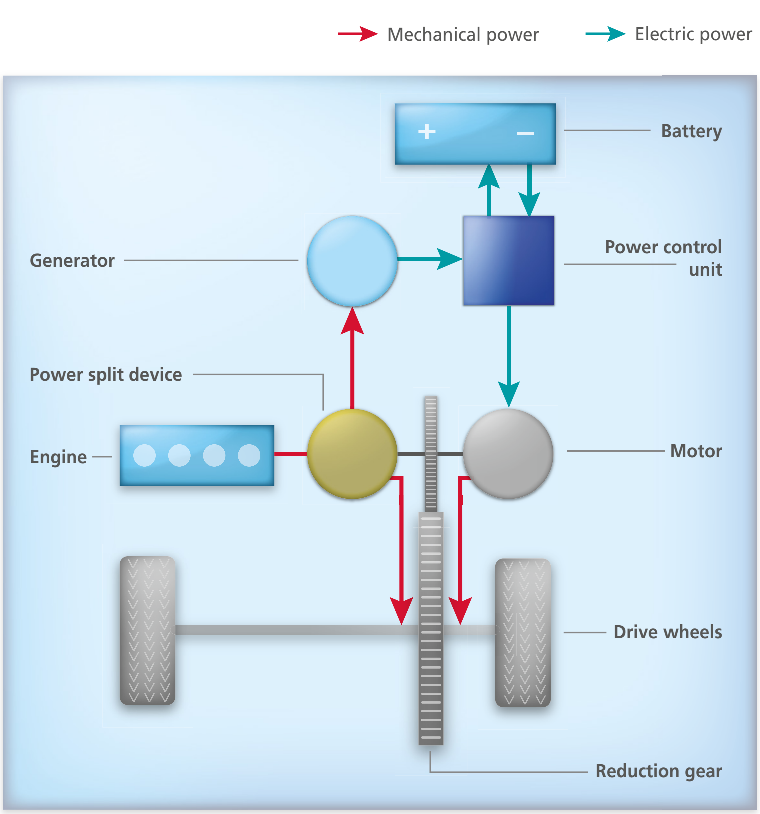
Reconsidering the Control Structure

In a first step, the entire control structure was fundamentally reviewed. The goal was to establish a simpler and more coherent structure. This allows even less experienced employees to understand the control structure faster, facilitates control design, and saves time during debugging. Furthermore, combining the new control structure with code generating tools makes it possible to improve production code efficiency.

Reconsidering the Development Process

An efficient development process consists of the minimum amount of steps in order to ensure the desired level of quality. After reviewing its earlier development processes, it became clear that the number of steps for overall control development could be reduced by implementing model-based development (MBD), which would let Toyota automate the implementation of an all-at-once development process with optimal tools and save labor. Toyota also learned that implementing tools makes compliance with ISO 26262 easier and allows for efficient quality assurance. In addition to the conventional inspection process, Toyota wanted to be able to productively collaborate with suppliers at later stages of the development process.

The power split device distributes the torques of the internal combustion engine and electric motor to the wheels and the generator.



Establishing a Model-Based Tool Chain

To reach the goals for a more efficient development process, Toyota is therefore trying to adopt a model-based tool chain that is based on the MATLAB®/Simulink® environment. The defined efficiency goals resulted in precise requirements for the tools that were considered to be suitable candidates at that time:

Improved development efficiency

Toyota chose the production code generator TargetLink® from dSPACE, which offers reliable automatic code generation and a consistent simulation concept from the model to the object code.

Securing quality that can stand up to actual implementation

Toyota uses the test tools BTC EmbeddedValidator and BTC EmbeddedTester from BTC Embedded Systems AG for quality assurance. They ensure that TargetLink models and generated code can be checked at the implementation level in fixed processes at the early stages of development.

Defining and applying modeling guidelines

The model-based Simulink/TargetLink development environment is suitable for structure-compliant modeling. The work of developers can be reduced by incorporating predefined modeling guidelines into the guideline checker MES Model Examiner® and thus automating the checks of steps. Furthermore, highly efficient production code

The combustion engine of the Toyota Prius. It connects directly with the electric machines and the power split device.

The power control unit controls all hybrid driving functions.

can be generated that sustains consistent modeling and is compliant with MISRA C.

Together with BTC, dSPACE supported the introduction of the new workflow at Toyota by providing comprehensive seminars and workshops that are immediately applicable to actual practice, in addition to engineering services. Toyota pursued a development process that was based on the ISO 26262 reference workflow for TargetLink and BTC EmbeddedValidator and EmbeddedTester.

Experiencing the New Tool Chain

The evaluation of TargetLink in combination with the test tools from BTC found that total man-hours can be reduced during the development process, including conventional inspection processes. Subsequently, this helped achieve the goal of quickly and accurately developing new functions. Toyota's system developers especially appreciate the fact that TargetLink operation flows can be automated relatively easily. Using this environment not only makes producing implementable code simple, it also supports Toyota's detailed needs for applying implementation information settings to an entire model block with, for example, a single click of a button. Moreover, while both Toyota and its suppliers each had processes for developing and inspecting code in the past, automating the implementation code generation and carrying out inspections using TargetLink and BTC EmbeddedTester reduced supplier man-hours as well. This made developing functionality in cooperation with suppliers easier.

Complete Validation

Although Toyota's conventional testing methods also adequately ensure code quality, they require a high number of man-hours. The formal verification used by BTC EmbeddedValidator automatically and completely verifies the consistency between specifications and models. The following examples are used to prove mathematically and conclusively that requirements are not violated:
Confirm that the following situation can be applied without exception to all combinations of input signals:

- In case a situation occurs where the battery cannot be used for some reason,
  - the vehicle invariably migrates to a drive mode that does not use the battery.

BTC EmbeddedValidator creates all possible value combinations for this

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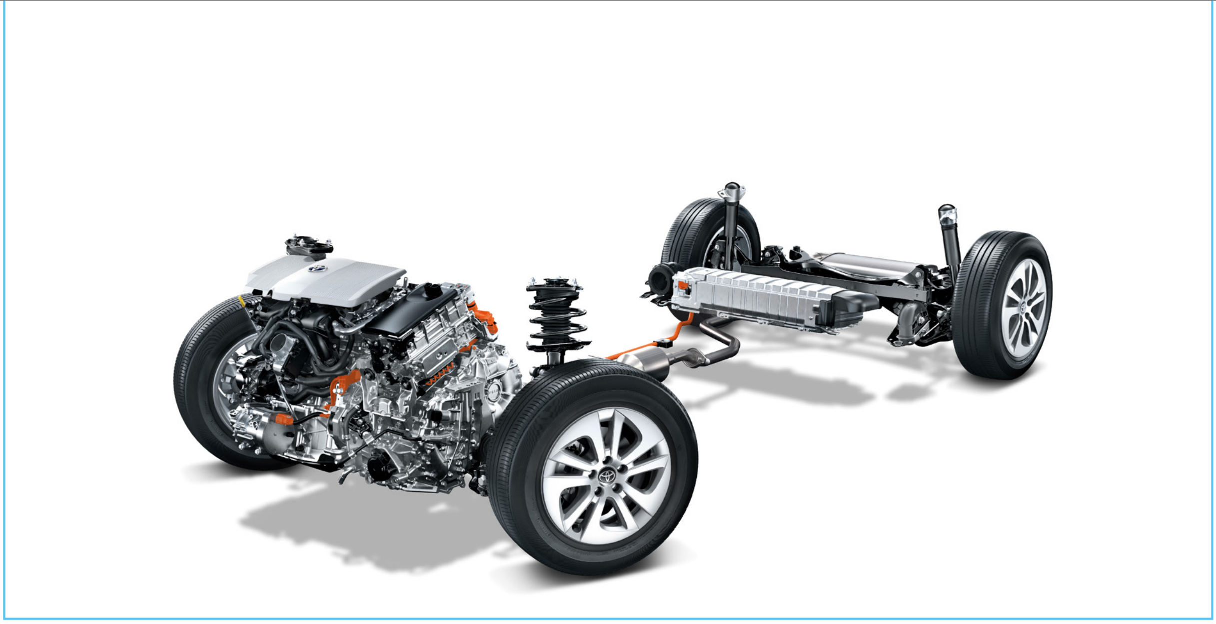


Setup of the electric drivetrain of the Toyota Prius 4.

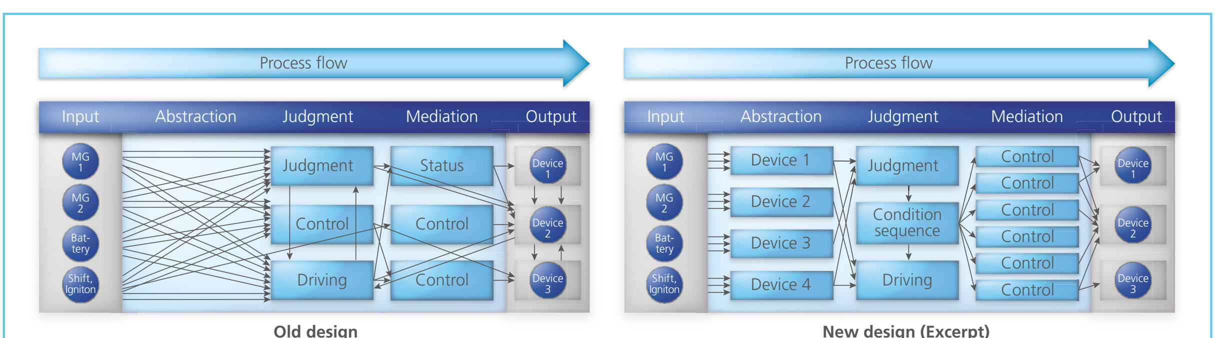
> "We established a basis for improving the efficiency of the entire development process, including inspection, by using TargetLink, BTC EmbeddedValidator, BTC EmbeddedTester, and related tool chains in conjunction with automation mechanisms."
>
> *Naoki Ishikawa, Toyota Motor Corporation*

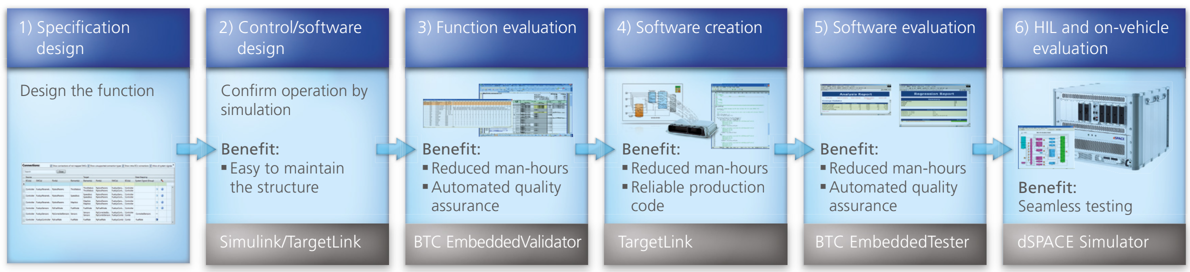
requirement and confirms and proves whether a counter example exists. Moreover, BTC EmbeddedTester offers fully automated back-to-back testing between Simulink/TargetLink models and the production code and automatically generates MC/DC code coverage test cases. In addition, the tool detects all problems in the code, such as value range violations and division by zero. The results include all produced vectors and can be confirmed using an automatically created report. During back-to-back testing, the target microprocessor (hardware) and the cross compiler (object code) are also incorporated in the tests, and provide a final validity confirmation. In doing so, TargetLink and BTC EmbeddedTester are combined to execute the processor-in-the-loop (PIL) simulation using the actual target microprocessor. This test step leads to more efficiency for ISO 26262-compliant validation.

Challenges and Future Prospects

Toyota implemented a variety of tools and environments, including an all-at-once development process, new processes, and automated mechanisms in parallel with the vehicle development. However, initially man-hours increased more than anticipated. It thus became clear that a proper process management had to be put in place that continuously monitors and optimizes the process. Further improvements to the efficiency of the development process and the tool chain as well as the development environment are planned for the future so that their merits become even more obvious to developers. For example, Toyota is investigating the intensified use of controller models in the early stages of development (virtual simulations with dSPACE VEOS®), the continued im-

The control structure before and after the optimization.





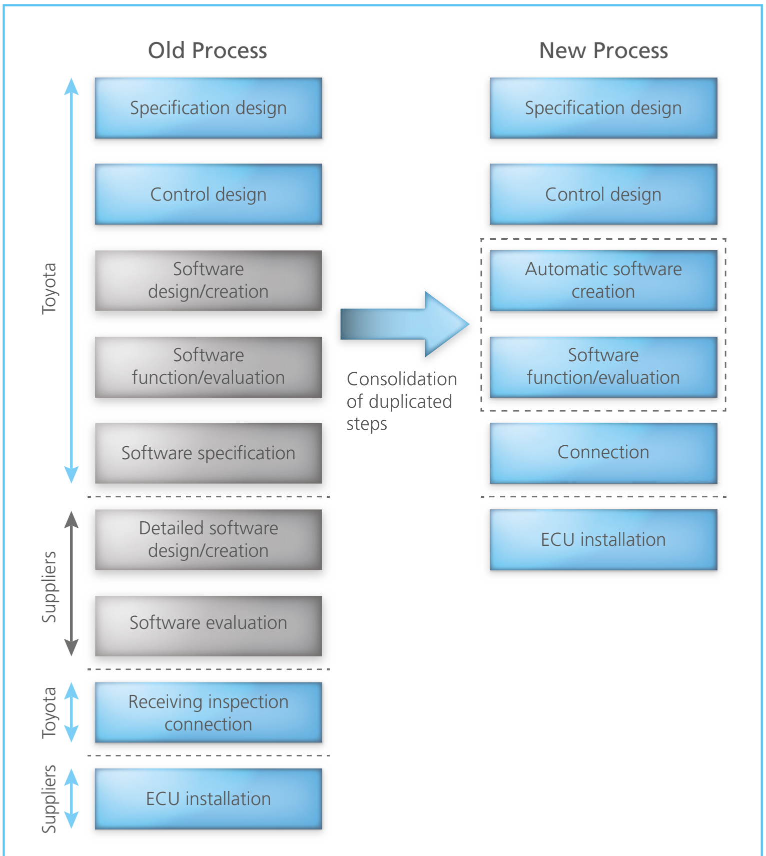
Advantages of each process and tool used in the development process during model-based implementation.

> "By applying the tools, we succeeded in paving the way for promoting more efficient hybrid vehicle development."
>
> *Shinichi Abe, Toyota Motor Corporation*

provement of the control development environment (e.g., component re-use, including test patterns, parameters, and models (xILS plants) using dSPACE SYNECT®), and the improved usability of the environment itself. ▪

Shinichi Abe, Naoki Ishikawa
Toyota Motor Corporation

The optimized development process is reduced to the minimum number of process steps and thus improves development efficiency.



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Shinichi Abe is the general manager of the Hybrid Vehicle Management System Development Division, at the Toyota Powertrain Company, TOYOTA MOTOR CORPORATION in Aichi, Japan.

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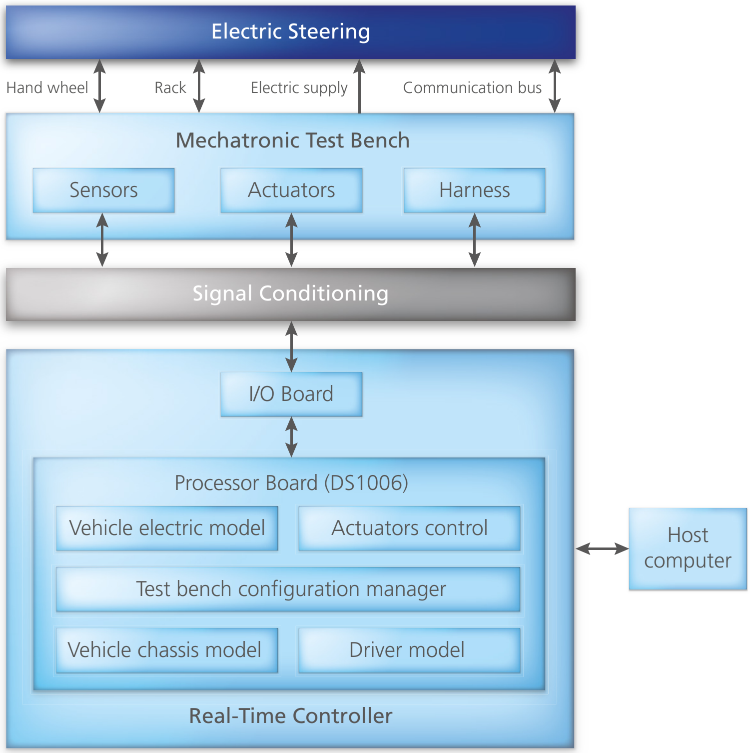
Automated fault injection tests for JTEKT steering systems

Inspect the unexpected

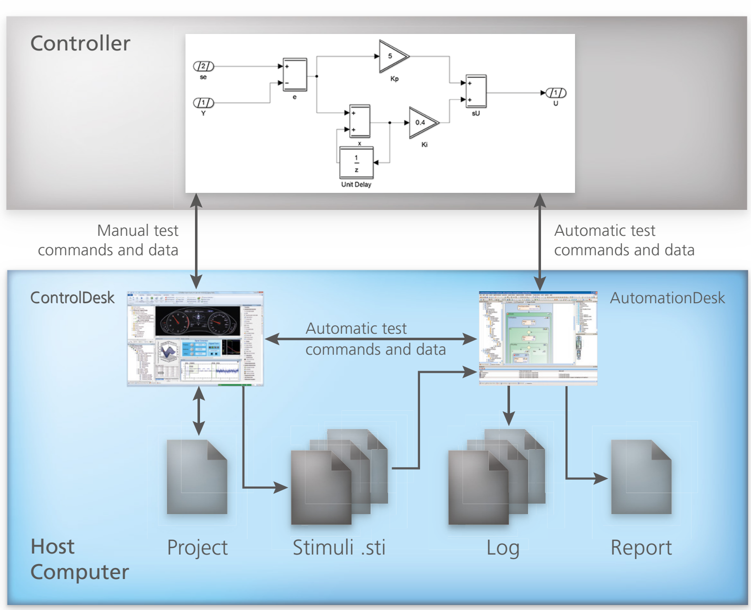
The steering control of a passenger car is a safety-critical component. Therefore, its fault tolerance has to be checked according to ISO 26262. Thanks to a dSPACE HIL simulator with automated fault injection, JTEKT can eliminate a large portion of potential inconsistencies long before a vehicle under test enters the proving ground.

Expect the unexpected? Complex controls in electric power steering systems often assist the driver noticeably in steering the vehicle. However, if these controls suddenly show unexpected behavior, the vehicle may quickly run off track. To avoid this and to demonstrate the required robustness, steering systems and their controls must be subjected to numerous fault injection tests before their market introduction. Generally, this means test drives on a proving ground. At the same time, the sharp increase in vehicle and function variants translates into a high number of test cases and rising expenses for real test drives. Due to the necessary safety precautions and the natural inhibitions of human test drivers, real road tests cannot cover the entire vehicle dynamics range. >>



Intelligent work division: The quad-core architecture of the DS1006 Processor Board enables JTEKT to distribute different calculation models of the test bench simulation to the individual processor cores and thus optimize real-time execution.

Perfect addition: The experiment and visualization software ControlDesk® not only enables JTEKT to manually control the steering test bench. With AutomationDesk in the background, ControlDesk also lets engineers configure and control all automation processes, such as fault injection.



ISO 26262 on the Rise

Another driving force for JTEKT is compliance with ISO 26262, the international standard for the functional safety of road vehicles. The standard includes several regulations for fault injection tests at system level. Among other regulations, it calls for a regression strategy of repeating test cases to ensure that modifications of previously tested software parts do not cause new failures. Tests that are not or only partially regressive are allowed only in exceptional cases and detailed reasons must be given as part of the certification process. For Automotive Safety Integrity Level D (ASIL D), ISO 26262 requires back-to-back testing during which the results of the tests at software level are compared to the test results at model level. These and other requirements of the safety standard, for example, for requirements management, software design, and the documentation of different work products throughout the development and verification process, lead to significant formal efforts in the development project.

Test Bench Testing for More Safety and Efficiency

To meet all these current requirements, manage the increased effort, and conduct the fault injection tests in compliance with ISO 26262, JTEKT Europe in Irigny, France decided to use a real-time-capable hardware-in-the-loop (HIL) test bench with integrated automated fault injection from dSPACE. This means that developers can frontload a large portion of their real road test program to a high-precision, reproducible simulation that also uses real components. As a result, the system is already very mature before the steering control is approved for further tests in a real vehicle under test. On the one hand, this reduces the risks for the test drivers. On the other hand, the HIL test bench also

> "The HIL simulator from dSPACE gives us a powerful system that can be continuously enhanced thanks to its open architecture."
>
> *Loic Bastien, JTEKT*

allows for the simulation of test drives in extreme situations, called boundary conditions in ISO 26262, that a human driver could never reproduce because of natural inhibitions. Therefore, the test bench provides a significantly higher test coverage. Another benefit is the ability to efficiently test different variants of the steering system without having to make time-consuming and expensive modifications to the vehicle under test.

Components of the Test Bench

The test bench for JTEKT Europe consists of a mechanical setup, a HIL simulator, actuators for the steering wheel and the rack, sensors for angles, forces and displacement of the rack as well as a signal conditioning interface and a host computer for the user interface. The HIL simulator uses a DS1006 Processor Board that executes a vehicle model to calculate how the force is applied to the rack and a driver model to simulate human behavior in certain situations. Aside from pure HIL operation, the handwheel and the rack actuators can be controlled independently. The respective changes in angle or torque and in force or displacement allow for the execution of very specific system testing.

Fault injection and Debugging

Because of its real-time capability and its powerful multiprocessor architecture, the dSPACE HIL simulator offers JTEKT a perfect tool for time-synchronous fault injection via the XCP protocol. The dSPACE tools can be included in a test automation, which means that the tests can be repeated at any given time. This minimizes the effort for repeated full tests, hence the regression strategy required by ISO 26262 can be comfortably put into practice at all times. As a result, JTEKT no longer has to invest time and effort into justifying excluded or incomplete regression tests.

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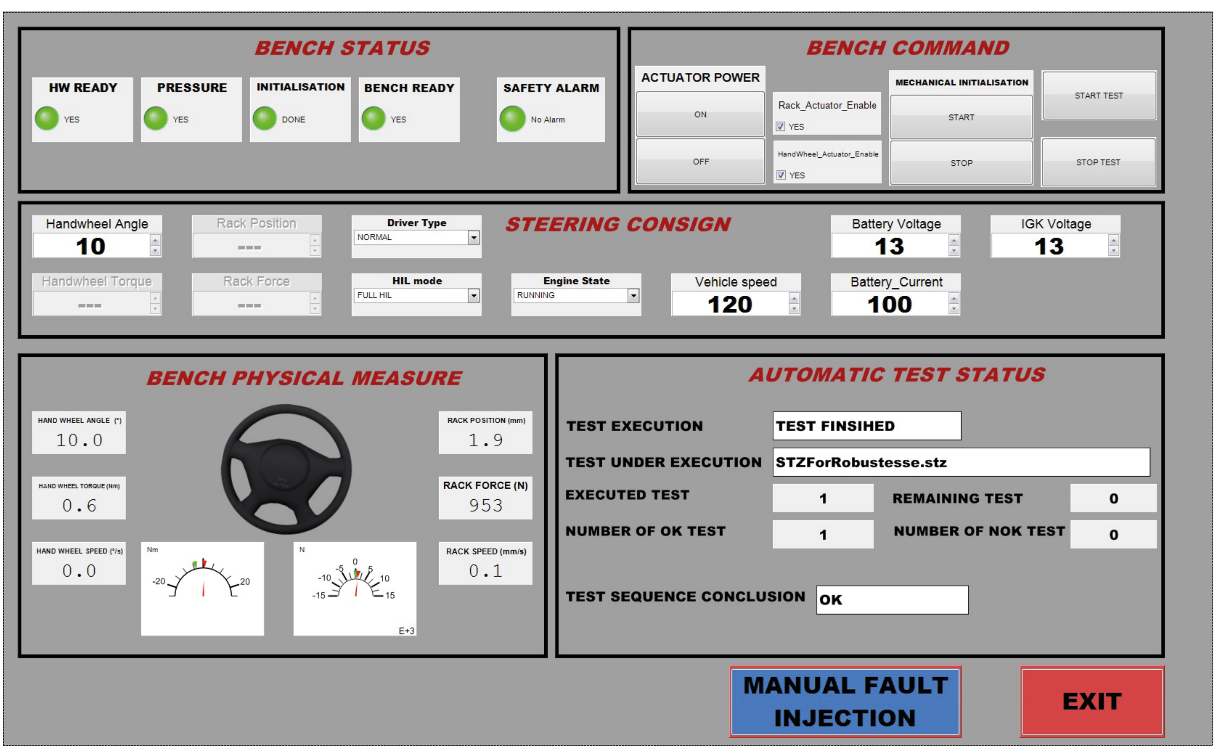
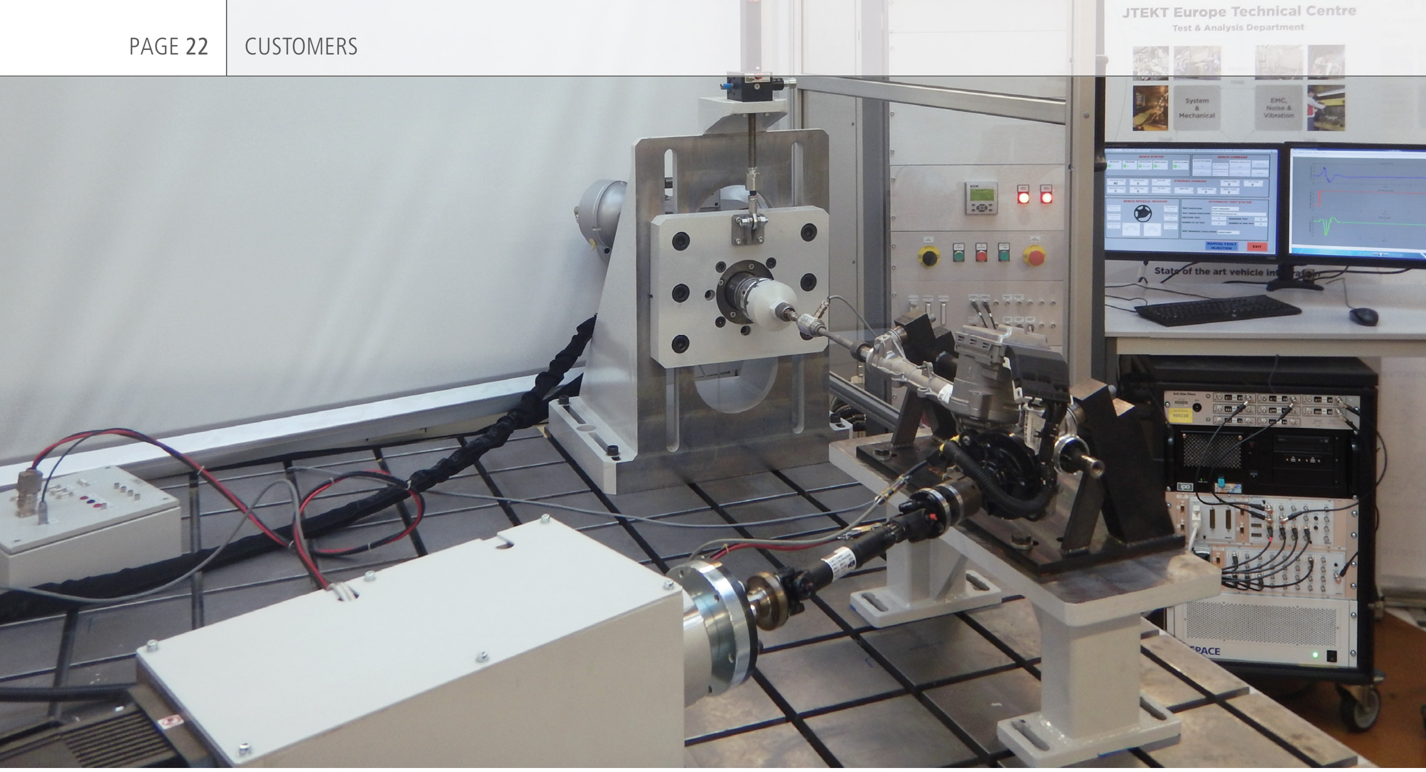
Virtual control center that is easy to configure: ControlDesk allows developers and test engineers to always fully focus on their current task.





Hardware-in-the-loop steering test bench from JTEKT: A large portion of their test program for fault tolerance can be frontloaded to a high-precision simulation with real components even before conducting real road tests.

Moreover, the fault injection tests are now simulation-based and carried out directly during the system test. Back-to-back testing as required by ISO 26262 can now be conducted in a simple manner: The same stimuli that were used for the model-based development of the functions can now be reused on the HIL test bench. The test bench uses the XCP protocol to also read internal data of the electronic control unit. This data can be used for debugging, for example. For a correct evaluation, it is very important that in both cases the data that is added on the basis of the XCP protocol is absolutely synchronous with the analog measurement data from the test bench sensors. For this, JTEKT uses the dSPACE RTI Bypass Blockset to easily carry out the complex data synchronization.

Automation Helps Control Variant Diversity

The test plan JTEKT uses to qualify a newly developed steering system for test drives in the real world consists of a variety of tests, all of which must be conducted for all planned variants of a platform. To meet the tight deadlines for delivering new software versions despite the high number of variants, JTEKT uses dSPACE AutomationDesk. This test automation software processes the test program in a reproducible manner and records the resulting measurement data.
Afterwards, AutomationDesk uses the recorded data and the evaluation blocks that contain the predefined test criteria and the respective fulfillment criteria to calculate the results of the fault injection tests and summarizes them in a detailed report for test engineers. Aside from the information on the passing or failing of a test required by ISO 26262, the report also provides details to specifically compare individual measurement data with the applied test criteria and to analyze potential deviations. AutomationDesk's ISO 26262 certification thereby drastically reduces the effort for classifying and qualifying the tools that are used in the context of functional safety for road vehicles.

Easily Configuring the User Interface

Test bench engineers can control all their tasks in one user interface created with dSPACE ControlDesk. This experimentation and visualization software lets engineers send individual actuator commands to the test bench, monitor their effects, and record them. It also lets them configure and control automation functions up to the final evaluation of the test results. In these cases, AutomationDesk always works in the background while ControlDesk permanently provides full transparency and control over the related operations in progress. ControlDesk is easy to con-

> "The efficient test automation with AutomationDesk has considerably increased the productivity of test operations that comply with ISO 26262."
>
> *Jean Michel Trebuchon, JTEKT*

Test Center of JTEKT Europe in Irigny: The HIL test bench is the perfect addition to the test drives with new steering systems that are conducted here. The safety of the test drivers is increased because many inconsistencies of the steering control can already be eliminated during the simulation.

figure and provides intuitive visualization options. This allows developers and test engineers to always fully focus on their respective task.

Summary and Next Steps

The HIL test bench and the tool chain from dSPACE helped JTEKT reach their primary goal, which was the automation of fault injection tests in the laboratory and compliance with ISO 26262.
As a result, the number of road tests with real vehicles was considerably reduced, which in turn saved significant amounts of time and resources. Moreover, test drivers are now using a system that has already been thoroughly tested, making their job much easier. In the future, the simulator might be used for even more tests, such as additional requirements-based HIL tests at system level. JTEKT is also planning to use recorded measurement data from real test drives on the HIL test bench instead of synthetic stimuli. This is easily possible because of the existing infrastructure and the seamless dSPACE tool chain. Developers can even use the 3-D visualization software MotionDesk early on to visualize how much a failure in the steering control lets the vehicle deviate from its planned track. This results in even higher test efficiency. Thanks to the dSPACE tool chain, JTEKT no longer has to worry about "expecting the unexpected". They can now thoroughly "inspect the unexpected".

Jean Michel Trebuchon,
Loic Bastien,
JTEKT Europe, France

Jean Michel Trebuchon
Jean Michel Trebuchon works as a test bench developer in the Test & Analysis department at JTEKT Europe in Irigny, France. He is responsible for the development of user interfaces and test automation software.

Loic Bastien
Loic Bastien works as a test bench developer in the Test & Analysis department at JTEKT Europe in Irigny, France. He is responsible for real-time modeling and bus communication.

Innovative front wheel suspension for SAME specialty tractors

Perfect Grip, Perfect Grapes

To give the specialty tractors of the Frutteto series the best possible driving safety and maneuverability, SAME developed the new Frutteto S/V Active-Drive series featuring an electronically controlled front wheel suspension with independent arms. The production code was generated with TargetLink.

> "The TargetLink Data Dictionary was a great help in centrally managing the high number of model variables and parameters of the ActiveDrive project."
>
> *Andrea Degiorgi, SDF R&D Department*

Nothing gets wine connoisseurs more excited than a good vintage. But all too often, the most excellent drops grow on the most challenging terrains. Steep hills, loose ground, and narrow paths require specialty tractors to cultivate and harvest the grapes. However, these tractors' narrow track and their high center of gravity bring additional challenges, as they make it difficult to ensure a good grip and safe propulsion in all situations.

Active Control Ensures Grip and Propulsion

To master these challenges, SAME developed the new Frutteto S/V ActiveDrive, equipped with a novelty in the specialized tractor market – an adaptive hydro-pneumatic front suspension with independent arms. Its electronic control ensures constant grip by automatically detecting wheel slip and activating a differential lock accordingly. It also uses two hydraulic cylinders to always keep the two arms of the independent suspension in an optimal position, even when connected equipment adds extra weight to the tractor. This means the tractor's weight distribution is continuously being optimized. In combination with a lower center of gravity, this gives the tractor more stability and ensures stable propulsion, even at the maximum steering angle of 53° or when driving in parallel to a hill. The numerous sensors for position, speed, steering angle, suspension, braking status, etc. open up even more possibilities for the control software to improve safety. For example, "Anti-Dive" prevents the front wheel suspension from diving when the tractor brakes, while "Anti-Rolling" automatically adjusts the stiffness of the suspension to the driving speed and steering wheel angle. This improves stability and grip both in the field and on the road. ActiveDrive therefore gives the Frutteto series a level of safety and ride comfort that had previously been unique to high-performance tractors.

Smart Controller Concept

ActiveDrive is controlled on the basis of input variables such as the steering angle, driving speed, angular velocity of each front wheel, position of the hydraulic cylinders, status of the brakes and all-wheel drive, and the mode selected by the driver. The control variables calculated by the controller are translated into commands for the solenoid valves, which adjust the locking effect of the axle differential as well as the oil flow and pressure in the two hydraulic cylinders of the axle suspension. This not only makes it possible to slide the cylinders in and out, but the closed loop control also adjusts the damping and stiffness to each driving situation.

Central Management of Variables and Parameters

The controller was developed in a model-based MATLAB®/Simulink®/Stateflow® environment and with

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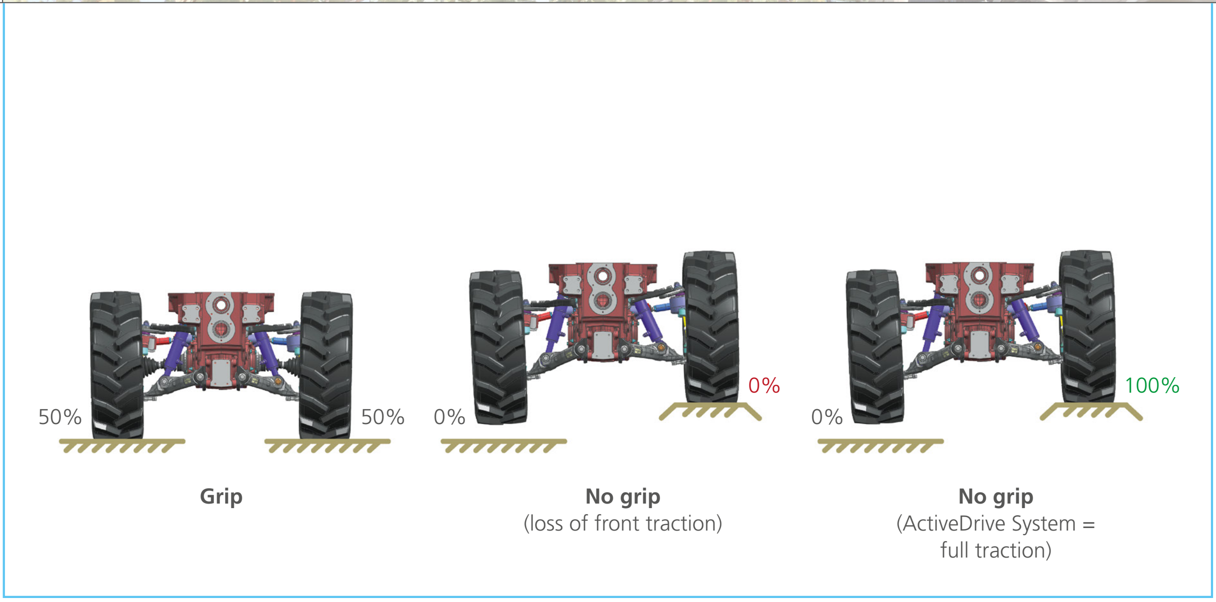


Front wheel suspension of an all-wheel tractor: Usually, the drive force is distributed between the front wheels. If one wheel loses ground contact, the entire drive force is lost due to the lifted wheel. The differential control of the Frutteto S/V ActiveDrive detects these states, rapidly activates the differential lock, and thus harnesses the entire drive force to the wheel that is touching the ground.

the production code generator dSPACE TargetLink®, which SAME had already used in some of its development projects since 2005. To manage the approximately 120 variables and parameters of the controller mode centrally, efficiently, and in a structured way, the developers extensively used the TargetLink Data Dictionary. Due to automatic code generation, the production code for ActiveDrive was available much sooner than usual and SAME achieved a markedly higher consistency between the code and the model than with handwritten code.

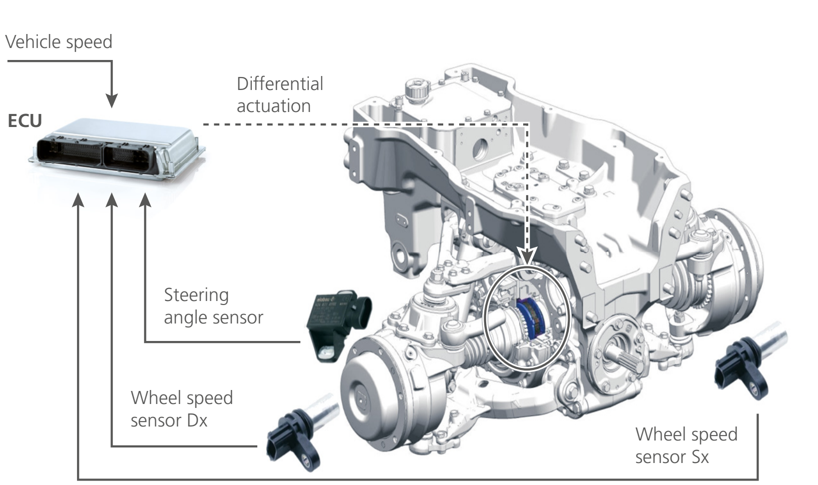
Comprehensive Simulation Options

Further improvements in development time and efficiency were made possible by TargetLink's three-stage simulation and verification concept, which allows for a quick and easy run through different simulation modes (model-in-the-loop, software-in-the-loop, and processor-in-the-loop) at the click of a button, thus ensuring early validation. Therefore, the software generated with TargetLink has a high level of maturity even before a mechanical prototype is available. At the same time, it was easy for SAME to integrate software variants, e.g., for different subsystems or parameter sets. Here, too, the developers benefited from the simple use of defined variables with the TargetLink Data Dictionary. Furthermore, they were able to test the control strategies of the Frutteto S/V ActiveDrive series together with models of the entire vehicle and the environment, making it possible to execute meaningful closed-loop simulations of the entire system behavior.

Reducing Time to Market

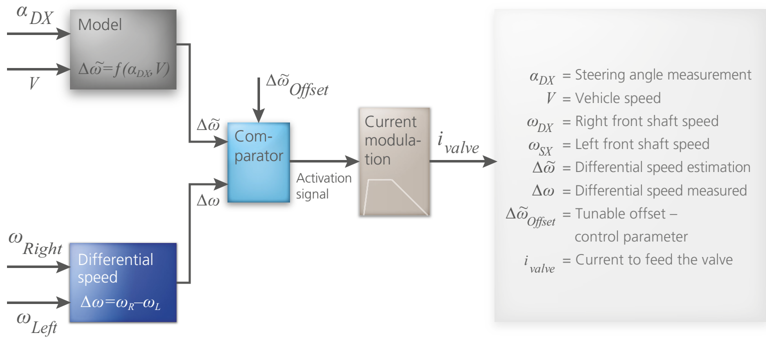
The simulation results were successfully validated on the test bench, on

Sensor arrangement: The control of the differential lock depends on the steering angle and the respective angular velocities of the front wheels.

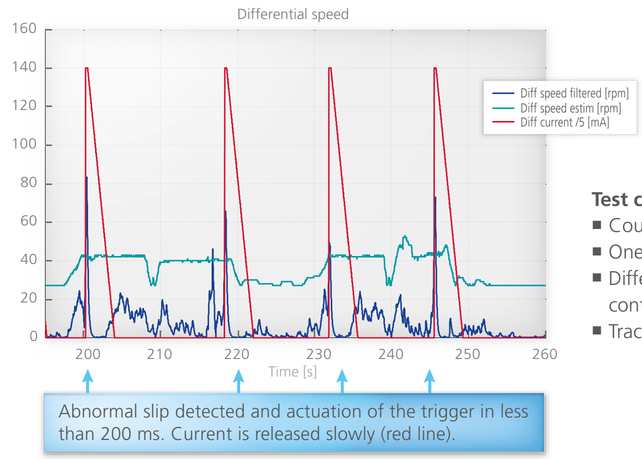


a tiltable platform, and in real test drives. In all these stages of validation, the Frutteto S/V ActiveDrive again proved that it is much more stable than conventional specialty tractors. Even at steep inclines with angles over 40° as well as on wet and loose ground, the tractor did not exhibit any weaknesses.
As a result, the Frutteto S/V Active-Drive achieved market maturity much faster than usual, not least due to automatic code generation with TargetLink. With this positive experience in mind, SAME plans to shift its future in-house software design processes entirely to a model-based environment and to use TargetLink for the transition to series production. But development efficiency and cost effectiveness were not the company's only achievements: Agriculture experts awarded the Frutteto S/V ActiveDrive with the Tractor of the Year 2016 award in the category "Best of Specialized". It seems like SAME has also created an excellent vintage. ■

Simone Tremolada,
Andrea Degiorgi,
Giorgio Gavina,
SDF R&D Department



Excerpt of the control architecture: The calculated control variables are output as commands for the solenoid valves (in this case of the differential).



Test conditions:
- Counterslope
- One wheel is lifted
- Differential traction control (DTC) active
- Tractor speed low

Diagram from the extensive test program for the Frutteto S/V ActiveDrive: The sensors detect an approaching wheel slip early on and activate the differential lock in less than 200 ms.

Simone Tremolada
Simone Tremolada is a system integration manager and Technical Project Leader for the ActiveDrive project at SDF in Treviglio, Italy.

Andrea Degiorgi
Andrea Degiorgi is an application software engineer for the Active-Drive project at SDF in Treviglio, Italy.

Giorgio Gavina
Giorgio Gavina is a senior system software engineer and powertrian software expert for the ActiveDrive project at SDF in Treviglio, Italy.

Developing morphing wing and tail elements

Fly Like a Bird

New knowledge in materials sciences and the continuous improvement of sensor networks open up new possibilities for adaptive aircraft technologies. At the University of Michigan, MicroLabBox plays a crucial role in testing these new designs with regard to data recording, actuator control, and the coordination of the experiments.

Giving airplanes the same maneuverability as birds is the dream of aircraft designers (pictured is a hunting falcon).

When developing morphing aircraft technologies, the Adaptive, Intelligent, Multifunctional Structures (AIMS) Lab at the University of Michigan frequently takes its inspiration from nature. Contrary to modern-day aircraft with their mostly stiff structures, birds can make more targeted use of their wings and tails to flexibly react to atmospheric conditions or changing air currents. This adaptability can be particularly useful for smaller aircraft, which, like birds, are influenced more by wind and weather than larger ones. The research at the AIMS Lab focuses on the development of aircraft that can actively and directly react to the surrounding air currents by adjusting their geometry, specifically the shape of their wings and tail. The AIMS Lab investigates these adjustment options to be able to develop an aircraft that uses nature as a model to adapt to the atmospheric conditions.

Morphing Wings – The Bird Flight Model

The ailerons at the wings play a central role in the aerodynamic control of aircraft, which makes them an important research topic in the field of adaptive aircraft technology. The AIMS Lab is investigating the effects of changing the shape along the complete wing surface with the help of Macro-Fiber Composite (MFC) actuators that are connected by elastomeric honeycomb structures (figure 1). This way, certain areas of the wings can be adjusted to minimize unwanted effects from air currents. This method is particularly suitable should the wing experience a sudden stall, a phenomenon where part of the wing significantly loses lift. By modeling the nonlinear aerodynamic behavior during a stall, the AIMS Lab can predict each actuator deflection required to optimize the wing shape in such a way that it compensates

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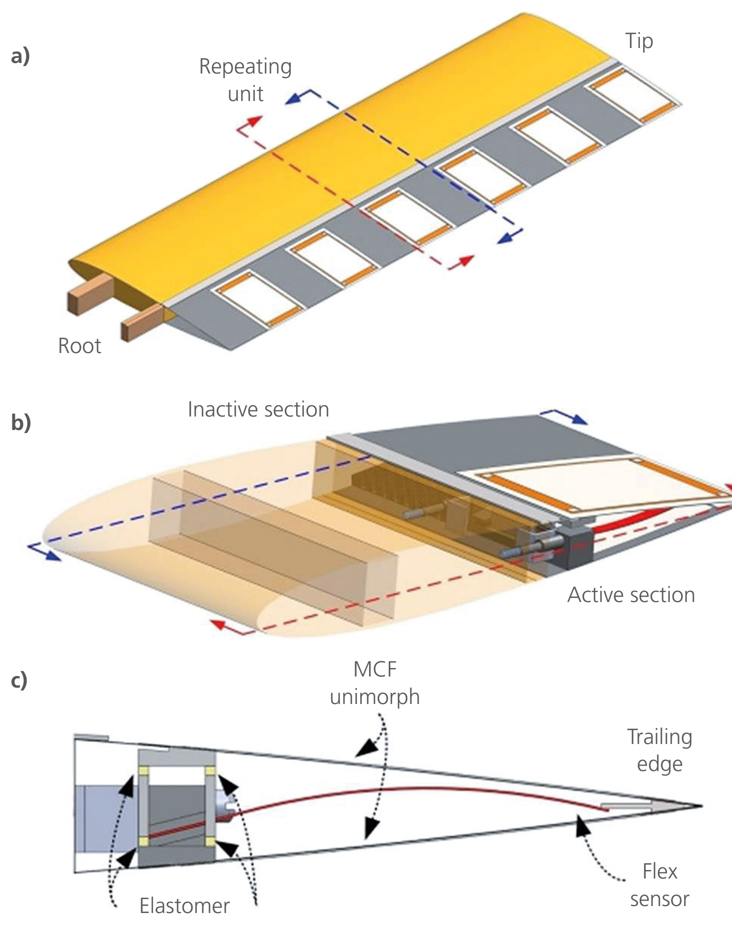

Figure 1: a) Configuration of the morphing wing b) Morphing unit section c) Active morphing mechanism. The MFCs change shape when actuated, deflect the tip of the trailing edge, and produce a cambered shape.

Lawren Gamble
Lawren Gamble is a PhD student in the Aerospace Engineering department of the University of Michigan, USA.

for the unwanted air current effects and re-establishes a stable flight without turbulence. This concept was inspired by biologists who observed that steppe eagles (Aquila nipalensis) intentionally trigger a stall to make rapid banked turns.

Adaptive Tail

Aside from morphing wings, the researchers at the AIMS Lab have also analyzed the air resistance of a moveable, horizontally aligned tail (figure 2). Its actuation mechanism is based on observations of the finely tuned quick movements that a bird makes with its tail while it keeps its head and body steady to watch its prey before launching a rapid and carefully targeted attack. This is the difference to a standard aircraft, where the tail merely ensures directional stability and control. An active tail is significant because it additionally allows pitch and yaw movements and can also work as an aerodynamic brake. An aircraft with an active tail would be highly maneuverable and nearly as versatile as a bird.

Crucial: Flexibly Changing Surface Shapes

A substantial challenge for adaptive aircraft is the development of methods to change the shapes of a surface (e.g., the wings and tail) so that they can seamlessly transition into one another. This is exactly what MFCs do. They consist of a thin, flexible structure that changes shape when high voltages are applied. This way, the MFCs can act both as a surface and as an actuator and are a lightweight alternative to conventional servo or hydraulics mechanisms in small unmanned aerial vehicles (UAVs). The integration of suitable honeycomb structures ensures a continuous changing of shape between the actuators, which reduces the formation of vortices and drag.

> "The ability of dSPACE MicroLabBox to record dozens of sensor channels and control multiple actuators with high precision helped monitor the complex structural and aerodynamic properties of morphing wings during wind tunnel testing."
>
> *Lawren Gamble, University of Michigan*

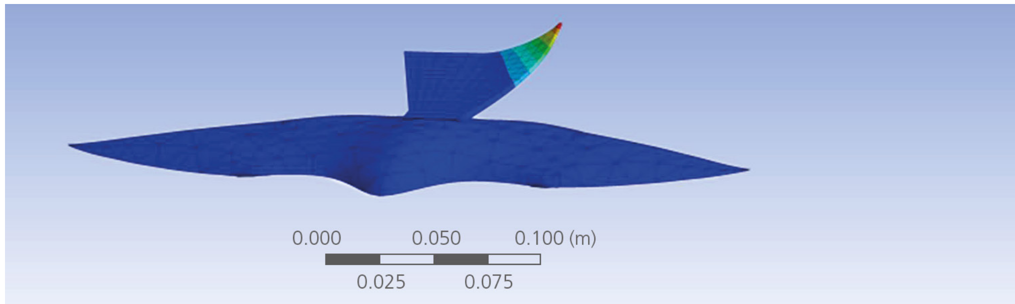

Figure 2: The results of the finite element method of a biomechanically inspired active tail demonstrate the resulting deflection when actuating the right half of the tail.

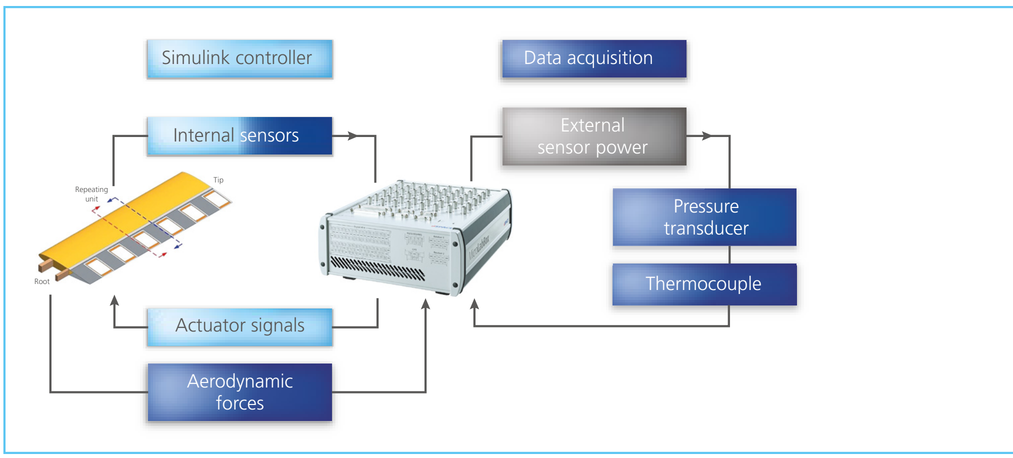

Figure 3: Schematic of the experiment setup and control system. MicroLabBox is the key instrument for controlling the actuator and recording data during wind tunnel tests.

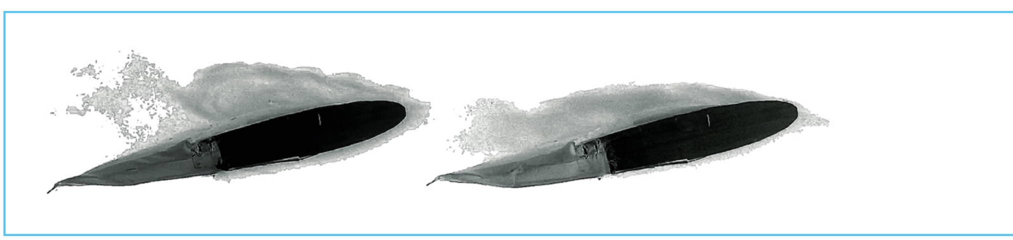

Figure 4: The visualization of the airflow shows the effect of adjusting the wing shape to stall conditions. Left: Strong formation of vortices due to no adjustment. Right: Wing adjustment almost completely suppresses vortex formation.

Another challenge is to set the ideal combination of actuator deflection for changing flight conditions. This is where the simulation of aerodynamics comes into play. Simply said, optimized simulation answers the question of which shape a wing needs to have to adjust to the current flow conditions. The result of the optimization determines the shape of each actuator and essentially predetermines the surface geometry of the entire wing span. The challenge then is to monitor the state of the wing geometry via internal sensors, control the suitable deflection for aerodynamic loads and record real-time data of aerodynamic forces and torques.

Wind Tunnel Tests with MicroLabBox

The aircraft constructions inspired by biology require extensive tests in the wind tunnel to measure aerodynamic forces and torques. This is where dSPACE MicroLabBox can demonstrate its performance power, because during these tests large amounts of data must be captured and actuators must be controlled with high precision. During the wind tunnel tests, the aerodynamic and structural properties of a scaled wing or even the entire aircraft must be captured and recorded for data processing and data comparison. Because these comparisons are usually intended to determine how well the adaptive structures are able to adjust to adverse flight conditions, the focus is put on precision and timing. Moreover, the MATLAB®/Simulink®-based work process with MicroLabBox also helps control and coordinate the complex experiments with the varied equipment.

Aiming for a "Fly-by-Feel" Adaptive Aircraft

MicroLabBox helped the researchers of the AIMS Lab come to three important conclusions. Firstly, in comparison to conventional rigid wings, the morphing wings significantly reduce air resistance. Secondly, the morphing wing handles a stall very well. This is clearly demonstrated by a reduction in vortex formation (figure 4). Thirdly, the adaptive tail can control the aircraft's direction and increases directional stability.

Based on these insights, the overall aim of this research is the development of a fully integrated fly-by-feel adaptive aircraft that has both a distributed sensor network and a tail and wings that adapt to the flight situation. ■

Lawren Gamble,
University of Michigan

Today, nearly every person living in an industrialized country starts their day consuming energy. Energy that is largely delivered by a centralized electricity grid. The electric alarm clock rings, people switch on their lights, make themselves a cup of coffee while television and radio make for their entertainment. Electricity affects many areas of modern life. Therefore, it is not very surprising that the National Academy of Engineering (NAE) has identified electrification as the single greatest engineering achievement of the last century. Imagine not having electricity available, which means no television, no radio, no electric light. This is the reality for 1.2 billion people worldwide. The World Bank reports that this is the number of people who still do not have access to electricity and 2.8 billion are still relying on solid fuels such as wood and coal to cook and heat their homes.

The Idea: Local Energy Systems

Professor Robert S. Balog and his students from Texas A&M University started a research project to give non-industrialized regions of the world access to electricity. Together, they want to make a difference, and they are working on a concept for a hybrid power distribution grid that is based on renewable energies.
A local area power and energy system (LAPES) that uses different loads, renewable energy sources, and storage technologies is at the core of this idea. The LAPES is intended to exist as a secondary feeder system alongside the central electricity grid. If required, it can be connected to the central electricity grid, but it can also be operated as a self-contained system, for example, in developing countries that do not have a consistent electricity grid.

Why LAPES?

"The international goals set in the COP21 Paris climate agreement make it clear that societies need to drastically shift from the current paradigm, which is based heavily on fossil fuels, to environmentally friendly energy systems," said Professor Balog. "The LAPES is envisioned as a community-scale electrical power system of the future, yet realizable in a faster time frame than a fully deployed futuristic smart grid." In developing countries, the LAPES could be constructed and connected with less rigorous regulations. In industrialized countries, it could also create additional pockets of electrical power when outdated electrical infrastructures need to be renewed. During the maintenance works, it would not be necessary to power off the entire grid.

Hybrid Power Distribution Systems with LAPES

In contrast to a centralized electricity grid, the LAPES provides direct current (DC) instead of alternating current (AC) and is much less complex. It is considered a "microgrid" because, with its individual components, it is a self-contained and much more compact grid. According to a 2015 report by Navigant Research, a market research and consulting institute, microgrids are expected to generate 1.4 billion US dollars annually by 2024. The main reason behind this positive outlook is that microgrids not only increase the share renewables have in the overall energy supply and promote economic optimization,

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Smart Grid –

An intelligent electrical grid which features a strong connection between energy generation, energy consumption control, and energy storage. The aim of smart grids is to achieve optimal balance between energy supply and energy demand.

Using solar energy as the basis for innovative hybrid electrical power systems

A Bright Future Ahead

Not everybody in this world has access to electricity 24 hours a day. This is why students from Texas A&M University are developing a concept for hybrid power distribution systems that could provide developing countries with reliable power supply. dSPACE tools supported their work on this innovative solution.

Figure 1: A student of Texas A&M University simulates hybrid power supply systems of the future.

- Cost-effective inverter systems for using alternative energy sources (including fuel cells, photovoltaics, etc.)
- Reliable power electronics with a service life of at least 40 years
- Distributed DC power systems with an emphasis on local/distributed control
- Auto-tuning coupled inductor filters
- Battery management, state-of-health management
- Non-linear control techniques such as model-predictive control
- Electrical safety such as arc fault detection

but these systems also promote grid resilience against power outages. If these DC microgrids were integrated into the existing AC grid at appropriate points, this would result in a new hybrid power supply system. However, before such microgrids can be used extensively, thorough theoretical feasibility studies are required.

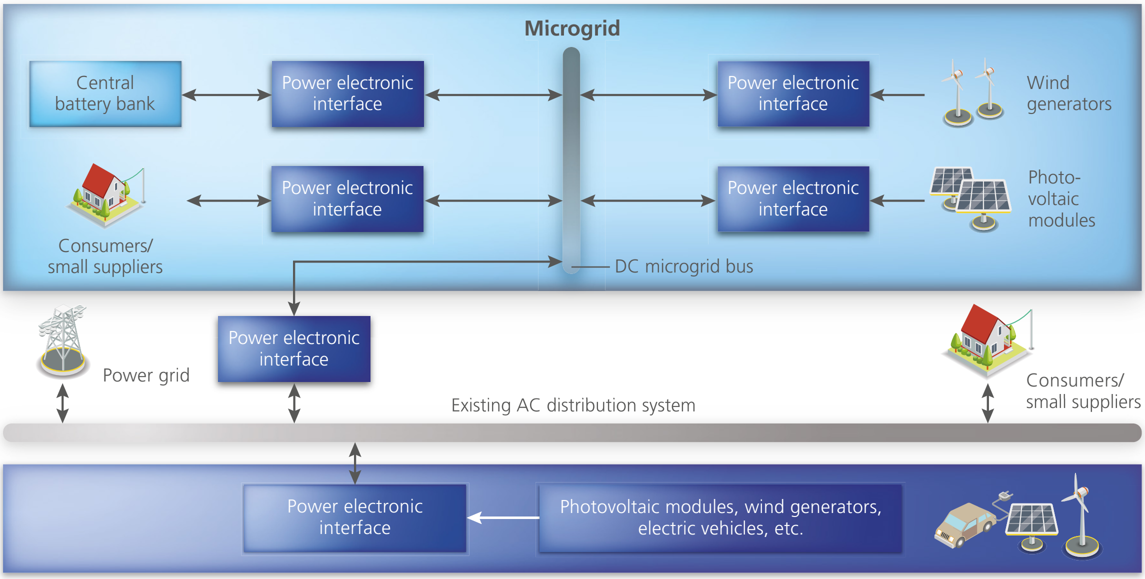
Focus on Electrical Energy Conversion

The team is currently investigating the fundamental engineering and scientific basis of electrical energy conversion. The areas they are conducting research in include:

- Converting solar energy into electrical energy (photovoltaics)

The team's main focus is on photovoltaic systems, which convert light directly into electricity. "Ultimately, our goal is to move photovoltaic energy out of the alternative energy category and into the mainstream portfolio of energy resources in a way that is technologically and economically sustainable," Dr. Balog said. "Our vision is to be an inter-

Figure 2: The students' vision is to develop a hybrid power distribution system where DC microgrids exist in parallel to the central AC grid and can be connected to the AC grid when necessary.



"Our goal was not to have just another tool in the lab, but instead to find the right tool. We therefore decided on using the development systems from dSPACE."

Professor Robert S. Balog, PhD, is Director of the Renewable Energy & Advanced Power Electronics Research Laboratory at Texas A&M University. Currently, he is teaching at Texas A&M University at Qatar.

nationally recognized center of excellence for research in this area."

Model-Predictive Control
A fundamental aspect to the LAPES project is model-predictive control (MPC). The team uses a model that can predict the future behavior of the system based on various elemental values such as sunlight. The results are then used for the continued development of the electrical supply system. The team focuses on three main areas: photovoltaic energy conversion, DC microgrid control, and multi-sourced hybrid energy system control. The students' vision is to develop an innovative, hybrid electrical distribution system that integrates DC microgrids based on renewable energies into existing AC grids (figure 2).

Real-Time Simulation with HIL Systems
After careful evaluation, Professor Balog and his students decided on a tool chain that is based on dSPACE products to carry out the necessary tests and examinations. An integral part of this tool chain is a hardware-in-the-loop (HIL) system in a dSPACE Expansion Box with a DS1007 PPC Processor Board. Thanks to the board's high-performance processing power, the team can simulate realistic environmental conditions for the power supply system and run various scenarios in real time. The algorithms of the model-predictive control are implemented on the test hardware using the dSPACE software Real-Time Interface (RTI).
The HIL system helps identify the supply system's reactions to changing basic conditions such as the weather. Moreover, the developed algorithms can be validated quickly in different applications. "With the dSPACE system, we are able to explore the full richness of the dynamic interactions of actual hardware," explained Dr. Balog. "This enables us to more fully characterize and understand system and subsystem interactions."
Therefore, the system is gradually developing from a first draft to a system that can be implemented under real conditions. As a result, the team will be able to set up a complete simulation of the planned hybrid power supply system in a fraction of the time it would have taken them to design and produce costly test hardware. ■

With the kind support of Texas A&M University

Conclusion

The students of Texas A&M University hope that their microgrid project will soon provide developing countries with a reliable electricity system. At the same time, they want to help renewable energies, especially photovoltaics, become a part of innovative energy supply concepts. Renewable energies are particularly suitable as the basis of hybrid power supply grids of the future. Therefore, Texas A&M University and dSPACE will continue to drive research in this area, so that hybrid power supply grids might soon play a decisive role in solving current issues in energy supply.

Multisensor All-Rounder

Developing algorithms for 360° environment detection on a compact and robust prototyping system

Highly automated vehicles require reliable 360° environment detection. The high amount of data that is generated by the sensors, such as camera, radar, and lidar, has to be synchronously captured, preprocessed, and fused. Therefore, dSPACE now combines the required sensor and bus interfaces with the latest NVIDIA processor hardware to build a uniquely compact and robust prototyping system for function development in the field of automated driving: MicroAutoBox Embedded SPU.

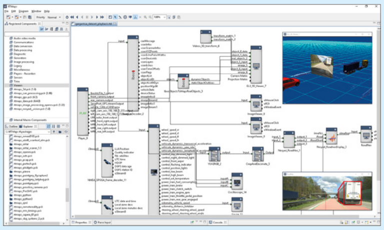
Ask any industry expert about the most important drivers of innovation in today's automotive industry, and they will say: highly automated and autonomous driving. Almost every OEM and tier-1 supplier as well as a high number of startups are already working intensively on these topics. And they are making progress that was inconceivable only few years ago. Current forecasts say that the first functions for highly automated driving will be available in series production very shortly. When they are, drivers will no longer have to constantly monitor these functions in specific traffic scenarios, such as automated driving on highways or autonomous parking. Moreover, research is already being conducted in the field of fully autonomous systems, such as robot taxis, which would render the "driving staff" obsolete.

Race Towards Autonomous Driving

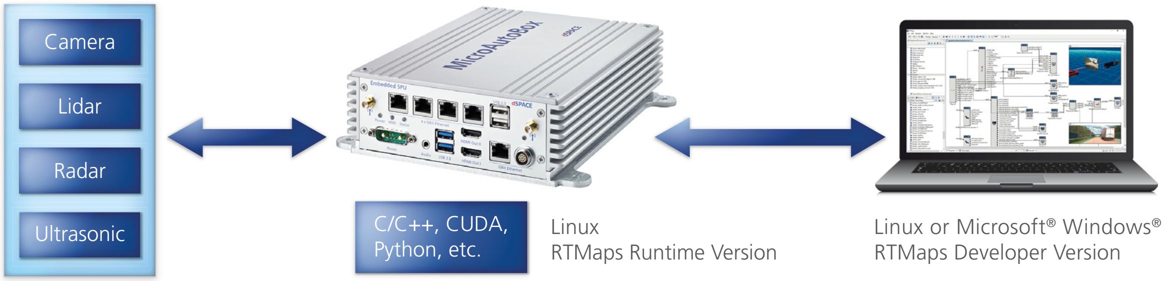
In this field, OEMs are practically racing each other to be the first to bring mature functions for autonomous driving to series production. But as innovation cycles are becoming shorter, the industry also faces the challenge of developing ever more complex algorithms in faster iterations, and test them in the vehicle very early on. This results in a very high demand for powerful prototyping systems that make function development convenient and much faster. The involved algorithms have to ensure that the 360° detection and assessment of the vehicle environment, which uses data from many environment sensors such as camera, radar, lidar, ultrasonic and GNSS sensors, is reliable at all times. Here, cameras and image data preprocessing play a central role. >>

RTMaps

RTMaps from Intempora, which dSPACE has distributed and used in its tool chain since 2016, is a component-based software development and run-time environment that lets users capture, time-stamp, synchronize, and process data from different sensors and vehicle buses. With the help of block diagrams and by integrating user-supplied C++, Python, or Simulink code, the tool creates a powerful environment for developing, testing and benchmarking complex algorithms for sensor and image processing as well as data fusion for multisensor applications. Extensive libraries for components such as cameras, radar sensors, laser scanners, and vehicle buses as well as data visualization, communication and preprocessing make function development easier. Due to the outstanding



performance on multicore x86 and ARM platforms as well as its high usability, RTMaps perfectly complements the dSPACE product portfolio.



Powerful and scalable: Embedded SPU used as a stand-alone system.

Challenging Sensor Data Processing and Fusion

A main challenge is preprocessing and fusing the high amounts of sensor and camera data. The associated algorithms are very computation-intensive and are usually performed on multicore CPUs and GPUs. The algorithms are typically implemented in the programming languages and frameworks of C++, CUDA, or OpenCL. This is why today consumer desktop PCs with an integrated graphics card are generally used to develop the algorithms in short iteration cycles. However, their high power requirements as well as their lack of robustness and reliability make them unfit for test drives in a real vehicle. If the hardware has to be installed in the trunk of a car, as is customary, a high amount of installation and wiring work is necessary. What is more, most desktop PCs do not have raw-data interfaces to the cameras used in production vehicles, such as GMSL interfaces. So how can you meet the high requirements for computing power and sensor interfaces while maintaining the compact size and robustness needed for in-vehicle use? dSPACE's answer to this question is a compact, robust and powerful Linux-based prototyping platform for the in-vehicle development of functions for autonomous driving: MicroAutoBox Embedded SPU (Sensor Processing Unit). Together with RTMaps, a graphical modeling environment for multisensor systems, it opens up entirely new possibilities for simplifying and accelerating the development of the underlying algorithms.

> MicroAutoBox Embedded SPU is a uniquely robust and compact solution for the vehicle-based prototyping of multisensor applications.

Profile: MicroAutoBox Embedded SPU

Product class:	■ Prototyping system for multisensor applications
Key functions:	■ Powerful multicore CPU with integrated NVIDIA® GPU ■ Interfaces for automotive bus networks, environment sensors, wireless communication, and GNSS reception ■ Intuitive graphical software environment RTMaps for the block-based implementation of algorithms ■ Optional data logging unit
Application field:	■ Function development for: ■ Advanced driver assistance systems ■ Highly automated and autonomous driving ■ Robotics applications ■ Data logging

High Processing Power and a Wide Range of Interfaces

MicroAutoBox Embedded SPU is based on the state-of-the-art NVIDIA® Parker architecture. It has a six-core 64-bit ARM CPU with an integrated NVIDIA Pascal GPU and 256 cores, which provides a processing power of up to 1.5 teraflops. But the high processing power is not the only unique feature of MicroAutoBox Embedded SPU. It includes interfaces to all

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Wide Range of Connection Options

Rear connectors:

1 1x GNSS antenna connector:
Receiving global satellite navigation data (GPS, GLONASS, Beidou, Galileo). If the satellite connection is interrupted, the uBlox NEO-M8U GNSS receiver uses inertial sensors to determine the exact position.

2 4x Gigabit Multimedia Serial Link (GMSL):
Connecting high-resolution cameras with GMSL interfaces for image processing. On request, a plug-on module can be used to support other camera interfaces.

3 2x HDMI 1.4b inport:
Connecting high-resolution cameras with HDMI interfaces for image processing. On request, a plug-on module can be used to support other camera interfaces.

4 2x LTE/Bluetooth antenna interface:
Support for wireless communication via LTE and Bluetooth.

5 Bus interfaces:
Connecting up to four CAN/CAN FD, two LIN (master/slave) and two BroadR-Reach interfaces.

6 1x Serial ATA interface (SATA III):
Connecting up to four SSDs for high-performance data capturing.

7 I/O interfaces:
Providing four Digital In, four Digital Out, and four Analog In channels.

8 1x SIM card slot:
SIM card slot for mobile communication.

Front connectors:

1 2x WLAN antenna interface:
Support for wireless LAN IEEE 802.11 n/ac.

2 4x Gigabit Ethernet interface:
Directly connecting Gigabit Ethernet-capable devices without a connected Ethernet switch. Each interface supports a data throughput of 1 Gbit/s.

3 2x Gigabit Ethernet interface (via internal switch):
Directly connecting Gigabit Ethernet-capable devices.

4 2x USB 2.0 interface:
Connecting USB 2.0-capable devices.

5 1x power supply:
6 to 40 V DC

6 1x jack socket:
Connecting microphones and audio output.

7 2x USB 3.0 interface:
Connecting USB 3.0-capable devices, e.g., cameras.

8 2x HDMI 2.0 outport:
Connecting two HDMI-capable displays. On request, one of the HDMI interfaces can be replaced with a module for controlling displays and driver information systems that will be used in the production vehicle.

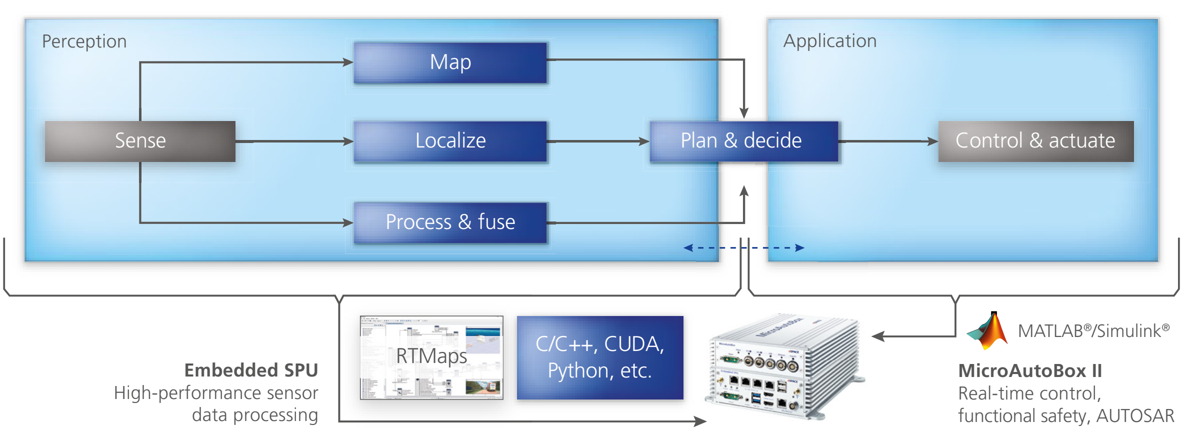
Technical Details
MicroAutoBox Embedded SPU

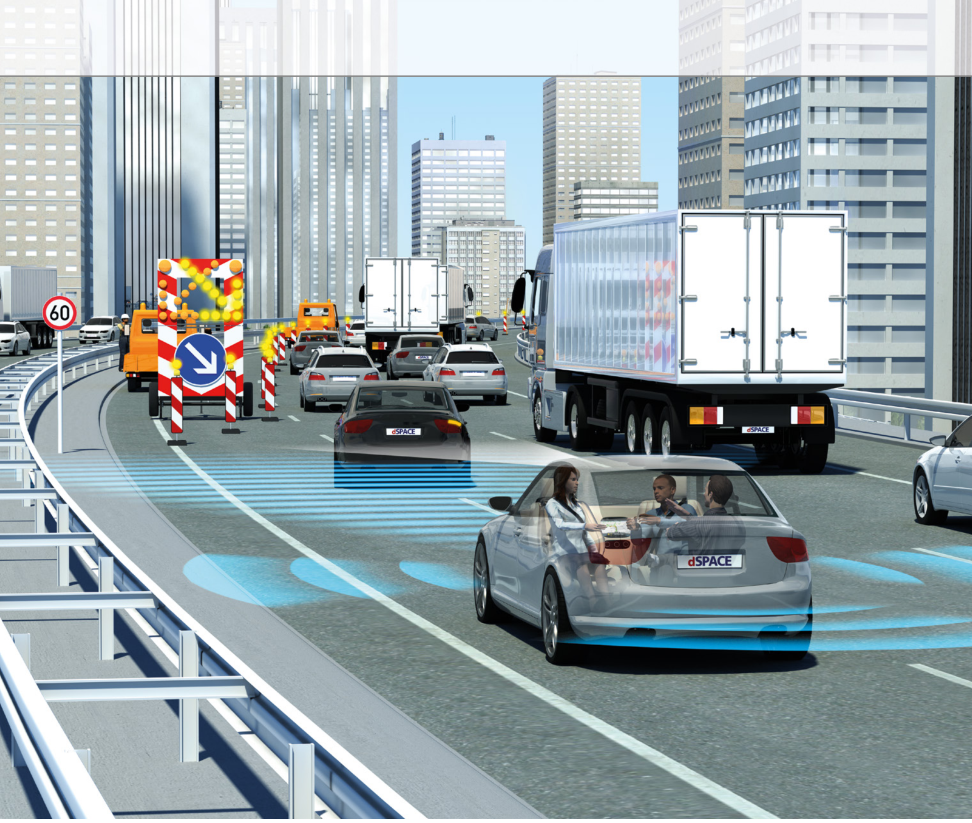
Parameter	Specification
Processor	■ CPU: Two NVIDIA® Denver 2 cores and four ARM® A57 cores (each with up to 2 GHz and 2 MB L2 cache) ■ GPU: NVIDIA Pascal™ with 256 cores at up to 1300 MHz
Memory	■ RAM: 8 GB 128 bit LPDDR4 RAM ■ Flash: 32 GB eMMC and 128 GB M2 card ■ Optional mass storage device
Operating system	■ Linux for Tegra by NVIDIA
Software support	■ Graphical development environment: RTMaps (Real-time Multisensor applications) ■ GPU programming language: NVIDIA CUDA® ■ Deep learning: NVIDIA TensorRT™, cuDNN® ■ Machine vision: NVIDIA VisionWorks™, OpenCV
Technical properties	■ Physical dimensions of enclosure: Approx. 200 x 225 x 50 mm (7.9 x 8.9 x 2.0 in) ■ Operating temperature range (enclosure): -20 ... +70 °C (-4 ... +158 °F)
Certifica-tions	■ MicroAutoBox Embedded SPU complies with current standards on electromagnetic compatibility as well as vibration and shock resistance, similar to MicroAutoBox II. Further details on request.

MicroAutoBox Embedded SPU is planned to be available in the third quarter of 2017.

common automotive bus systems, to environment sensors such as cameras, radars and lidars, to GNSS positioning, and wireless communication. MicroAutoBox Embedded SPU combines all this in a robust and compact housing for in-vehicle use. Another unique feature of MicroAutoBox Embedded SPU is that software developers no longer have to deal with the cumbersome programming of the individual sensor and output interfaces. Instead, they can focus completely on implementing their algorithms for sensor data preprocessing and fusion. To make this possible, MicroAutoBox Embedded SPU is closely integrated with RTMaps, a graphical modeling and run-time environment for multisensor systems (see info box on page 37). RTMaps is intuitive and provides all the interfaces of the Embedded SPU as ready-to-use libraries and I/O blocks. In RTMaps, developers have to implement only the actual algorithms in C++, NVIDIA CUDA®, Python, or via Simulink code integration. In addition, the system is ready for the use of dedicated software frameworks for deep learning (artificial intelligence) and machine vision.

Compact and robust prototyping system for developing functions for automated driving: Embedded SPU as an extension to MicroAutoBox II.





Stand-Alone Solution and Combination with MicroAutoBox or Other SPUs

MicroAutoBox Embedded SPU can be used as a stand-alone system or in one housing together with one of the standard variants of MicroAutoBox II. In combined use, the real-time application (real-time control, mechanisms for functional safety, integration of AUTOSAR Software Components) runs on the standard MicroAutoBox II while the Embedded SPU processes and fuses all sensor data needed for the control. To improve the processing power and increase the number of interfaces even further, it is also possible to connect multiple MicroAutoBox Embedded SPU systems to each other. In this case, RTMaps ensures clock synchronicity and the perfectly synchronous computation of all algorithms on the distributed systems. In addition, an optional data logging extension is available with an SSD memory of 8 terabytes, for example. The extension makes it possible to precisely record and replay the captured sensor data in perfect synchronicity.

Conclusion

Whichever combination a customer chooses: The synchronous capturing, processing, fusing, and replaying of large amounts of sensor data in such a robust and compact system makes MicroAutoBox Embedded SPU an exceptionally useful tool. Whether used for the development of highly automated, autonomous and self-driving vehicles or other robotics applications: The system consisting of MicroAutoBox II and MicroAutoBox Embedded SPU raises the bar for the in-vehicle prototyping of multisensor applications to an entirely new level. ■

> Together, MicroAutoBox Embedded SPU and RTMaps form a very powerful development environment for all types of multisensor applications.

Strategic Enhancement of the MicroAutoBox Product Range

For over 15 years, dSPACE MicroAutoBox has set the standard for in-vehicle rapid control prototyping for automobile manufacturers. With its focus on fast real-time control, it covers a wide range of automotive applications, from innovative combustion engine control and alternative drive concepts to modern driver assistance systems.
The next step is now taken by MicroAutoBox Embedded SPU, which particularly covers multisensor applications based on camera, radar and lidar sensors, for example. dSPACE thus specifically adds to the MicroAutoBox product range with a flexible and powerful system for sensor data preprocessing and fusion. Therefore, the Embedded SPU further strengthens the position of the MicroAutoBox product line as an industry standard for all prototyping applications, from A as in “autonomous driving” to Z as in “zero emissions”.

One for All

ASAM XIL API decouples tests of all test stages from the test platform

Efficient ECU testing requires reusable test cases that can be applied throughout the complete development process to achieve consistent test conditions. The XIL API standard provides the basis for this. It lets users set up test cases in the same manner – independent of test stages and platforms.

The successor to the HIL API standard, the ASAM XIL API standard V2.0, which was released in 2013, is the current standard for testing ECUs and simulating their environments. The X in the name symbolically represents the versatility of this standard, which can be used across different manufacturers and development stages. It supports developers of ECUs and test systems throughout the complete development and test process, which includes model-in-the-loop (MIL), software-in-the-loop (SIL), processor-in-the-loop (PIL), and hardware-in-the-loop (HIL) simulation.

A Standard That Opens New Doors

There is an abundance of companies in the market, and the number of software and hardware solutions for testing ECUs and simulating their environment is just as countless. This means: Components can be combined with one another without any problems only if they all have the same interfaces. For this purpose, renowned representatives of the automotive industry developed the XIL API standard. By supporting this standard, dSPACE shows its openness towards third-party products: If necessary, these products can be integrated into the seamless dSPACE tool chain extremely fast and without prior configuration.

ASAM XIL API

XIL API is designed to be an active standard. The ASAM XIL API workgroup is focused on continuously developing and optimizing the standard to meet new customer requirements. Regular XIL cross tests are performed to ensure the high quality of the standard. During these events, end users and tool suppliers define the use cases and functions to be tested, incorporating direct feedback from the real world into the optimization process.
To cover the diverse tasks in the areas of simulation and testing, several standardized interfaces with different functionalities are available for the simulation platforms. The XIL API Model Access Port (MAPort), for example, allows for read/write access to the simulator as well as the stimulation and the measurement data acquisition in all phases of the development process. Electrical error states, such as short circuits and interruptions caused by a Failure

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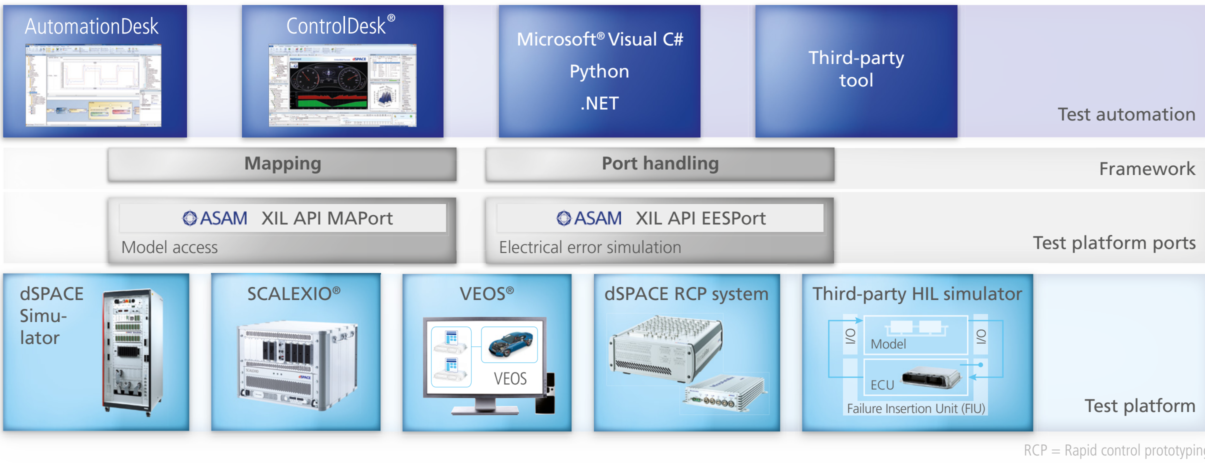

Figure 1: Because dSPACE products support the interfaces XIL API MAPort and XIL API EESPort, they can be effortlessly combined with XIL API-compliant products of third-party suppliers.

Insertion Unit (FIU), can be controlled via the XIL API Electrical Error Simulation Port (EESPort). XIL API benefits from using additional standards, among them ASAM Measurement Data Format (MDF) for saving measurement data and ASAM General Expression Syntax (GES) for the standardized description of trigger conditions, such as starting and stopping measurements and stimulations.

New Features

Today, the ASAM XIL API standard is a staple in the world of simulators – many users have already switched to XIL API to benefit from the new functionalities. An important innovation is the additional abstraction layer (framework) between test automation and simulation platform. It lets users transfer test cases to different test systems and reuse them throughout the complete development process – from MIL to SIL, PIL, and HIL. An important function of the framework is mapping: For this, aliases are assigned to the actual simulator variables to let users access the variables independently of the respective model structure. Thanks to this abstraction, the tests can be set up in the same manner and reused independently of the simulation platform or the test stage. Changes in the model can be maintained centrally in the mapping of the test tool. A cross-platform and cross-test stage use of the same test tools significantly minimizes the training effort for employees and simplifies the knowledge transfer between different teams.
Because the XIL API interface supports all .NET-compliant programming languages, such as Visual Basic .NET, C#, Python, and MATLAB M scripts, it can be easily integrated into different tools.

XIL API in dSPACE Products

As one of the ASAM founding members and a member of the XIL API workgroup, dSPACE has been actively participating in implementing and optimizing the XIL API standard since the very beginning. Whenever the standard is improved, dSPACE implements these improvements into its products in a timely manner. Thus, all HIL API interfaces were replaced by new XIL API interfaces for dSPACE Release 2016-B. The new XIL API interfaces fully cover the old RTPLib and HIL API functionalities and add new features.

"Thanks to XIL API, tests can be reused across all development stages, and products from different manufacturers can be combined. This creates an unprecedented freedom for choosing products and at the same time ensures continuity during testing."

Dr. Rainer Rasche, head of the ASAM XIL API workgroup and group manager in Product Development at dSPACE GmbH

For uniform access from test automation tools such as AutomationDesk to all dSPACE simulation platforms, the Platform API Package features the XIL API MAPort server. In the Failure Simulation Package, the XIL API EESPort server supports uniform access to dSPACE Failure Insertion Units. ControlDesk® includes the XIL API MAPort platform, which can be used to seamlessly connect simulation platforms from third-party suppliers or measurement tools, for example. This way, measurement data of third-party and dSPACE platforms can be recorded time-synchronously in ControlDesk, visualized in a plotter, and compared in one time domain. With the XIL API EESPort GUI component, which is integrated in ControlDesk, electrical error states can be configured and applied interactively via a uniform graphical user interface in ControlDesk. The Signal Editor in ControlDesk and the editor for signal-based testing in AutomationDesk use the XIL API standard to describe the signal waveforms for the stimulation and description of the reference signals in a standardized manner. It is possible to define and exchange complete tests in AutomationDesk by adding small enhancements to the signal description.

Switching Made Easy

For AutomationDesk users who already worked with HIL API for model access, the switch to the corresponding XIL API happens automatically. Users who created tests on the basis of scripts and now want to switch to XIL API receive comprehensive support for their migration process through documentation in the dSPACE Support Center or by the dSPACE Support team. If necessary, employees from the dSPACE Engineering team will assist users with the migration process, so nothing stands in the way of using the powerful XIL API standard. ■

XIL Cross Tests

To check the compatibility of test systems across different suppliers in the automotive industry, renowned suppliers of development tools regularly conduct XIL cross tests. During these tests, they connect their test tools to platforms of third-party suppliers to evaluate whether their test software can communicate with the test hardware of other manufacturers without problems. On July 13 - 14, 2016 cross tests were carried out at dSPACE in Paderborn.

For more information on this event and the cross tests in general, refer to the dSPACE website: www.dspace.com/go/xil_crosstests

Support

For more information as well as documentation supporting the migration, refer to: www.dspace.com/support

Let's Talk Innovation

Users, interested parties, and product experts met at the 8th dSPACE User Conference for an insightful exchange of information

The auditorium.

The e-bike with serial drive by IAI GmbH.

Dr. Herbert Hanselmann, CEO of dSPACE GmbH, opens the conference.

In dialog.

How can you validate radar sensors in a closed loop? How can you drive millions of test kilometers in early development stages? The 8th dSPACE User Conference was an exciting and informative platform for discussing these and similar questions to current development trends. Approximately 250 participants met on November 15 and 16, 2016, at the NH München Ost Conference Center to exchange technical information. On the first day, the customers gave intriguing insights into their ongoing projects, methods, and development processes. The second day of the conference provided a combination of interesting seminars by dSPACE experts on topics such as ISO 26262, e-mobility, ADAS, and automotive networks. But the presentations were not the only source of inspiration for the conference participants. The lively discussions afterwards were just as useful. The seminars in particular provided a great opportunity to share experiences. There were lively discussions on the ISO-26262-compliant validation of ECUs with HIL simulators and informative QA sessions on the future validation of autonomous vehicles. The participants had the opportunity to closely examine and try out the current test and development tools in the exhibition that took place at the same time. This included the latest developments, such as a mechatronic radar test bench, a steering test bench, an ADAS prototyping system with many different interfaces and computation power for environment sensors, as well as a platform for cluster simulation, which can be used to drive millions of virtual test kilometers. The first conference day ended with a dinner event at the "dSPACE Alm". Here, the participants had the opportunity to continue their discussions in a casual atmosphere and a cozy, typically Bavarian environment. dSPACE would like to thank all participants and the exhibitors MathWorks, BTC Embedded Systems, MES, DMecS, and IAI. We are already looking forward to the 9th dSPACE User Conference!


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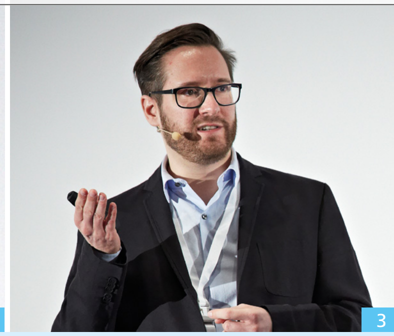
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Speakers:

1. ***Dr. Stefan Schmerler, Daimler AG***
   Dr. Schmerler presented the E/E test processes and methods at Mercedes-Benz. By using a combination of virtual and real ECUs with dSPACE Simulators and offline simulators, the company drastically accelerated the validation process and laid the groundwork for digital test drives.
2. ***Dr. Maximilian Miegler, AUDI AG***
   Dr. Miegler talked about "Developing and mastering highly networked vehicle functions step by step". His "barrier-free" simulation solution that includes everything from purely virtual tests to HIL tests to complete setups is a particularly efficient solution.
3. ***Daniel Frechen, Volkswagen AG***
   Mr. Frechen presented the use of a chassis HIL for maneuver-based function development. With a high-quality vehicle dynamics simulation on a dSPACE Simulator, evaluating networked vehicle functions and their effectiveness is more cost-effective and can be done earlier than in a real test drive and on the existing test benches.
4. ***Sascha Getos, BMW AG***
   Mr. Getos presented a practical example for the virtual validation of ECU software with dSPACE VEOS®. He configured the system via remote access and showed how to set breakpoints and reach them after a certain threshold value.
5. ***Dr. Thomas Herpel, Automotive Safety Technologies GmbH***
   Dr. Herpel talked about testing functions for vehicle safety on the basis of real data and simulation data. A SCALEXIO® system is used with simulated driving scenarios and data replay to evaluate pre-crash scenarios and in-crash events.
6. ***Ralf Arens, CLAAS Selbstfahrende Erntemaschinen GmbH***
   Mr. Arens presented a central test management solution based on dSPACE SYNECT®, which can be accessed by all German CLAAS locations. In 2016, this solution was used to manage 20,000 test cases.
7. ***Thomas Hackemüller, Ford-Werke GmbH***
   Mr. Hackemüller introduced a test system for validating camera-based driver assistance systems. The ECUs can be tested with a SCALEXIO simulator and faults can be inserted to test the vehicle behavior.
8. ***Jan Peelaerts, EUTOMATION & SCANSYS Sprl***
   Mr. Peelaerts told the participants how the company redesigned a load test bench for continuously variable transmissions in only 13 weeks. With dSPACE hardware and software it was possible to develop a high-performance controller.
9. ***Serge Klein, RWTH Aachen***
   Mr. Klein presented a combination of a simulator (SCALEXIO) and an engine test bench, which was used to test the combustion engine on the basis of driving maneuvers (engine-in-the-loop). Benchmark measurements between the reference vehicle and the test bench showed large agreement.
10. ***Oliver Graßmann, Ford-Werke GmbH***
    Mr. Graßmann talked about in-house function development according to ISO 26262. The methods and processes are implemented with a tool chain that is based on TargetLink®, BTC Embedded Tester, and MES MXAM.
11. ***Holger Jakobs, WABCO GmbH***
    Mr. Jakobs presented the model-based development process of his company. To comply with ISO 26262 and AUTOSAR, WABCO uses the production code generator TargetLink®.
12. ***Benjamin Freudenberg, Technische Universität Berlin***
    In his presentation titled "Modulation, controller synthesis and network synchronization of multilevel inverters", Mr. Freudenberg showed the participants typical problems of power electronics. He was able to develop his solutions with MicroLabBox.

The presentations of the 8th User Conference in German:

www.dspace.com/go/dMag_20171_UC


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Company day care center already part of life

Investing in the Future

High-quality childcare is crucial for combining work and family life. With its own day care center, dSPACE gives its employees one less thing to worry about.

In August 2015, Paderborn's first company day care center, dSPACE Dötze, opened its doors on the dSPACE premises. There are four classes to take care of up to 60 children between 6 months and school age. The center is run by the experienced day care center operator Impuls Soziales Management e.V. Its construction was supported by the Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (BMFSFJ). Project coordinator Angelika Hanselmann: "To make sure parents can quickly return to their workplace, they need to know their children are in good hands."
The day care center offers conditions that are tailored to the needs of the employees. For example, it only closes between Christmas and New Year's and one other day. The portfolio is rounded off by demand-oriented opening hours, the close proximity to the workplace, and quality factors like the above-average teacher-to-child ratio and the innovative teaching concept that focuses on MINT topics, bilinguality (German/English) and animal-assisted education. ■

Spacious rooms with high-quality equipment and a stimulating outdoor playground.

Brushing teeth together in a child-appropriate bathroom.

Support for children in all areas of development and education.

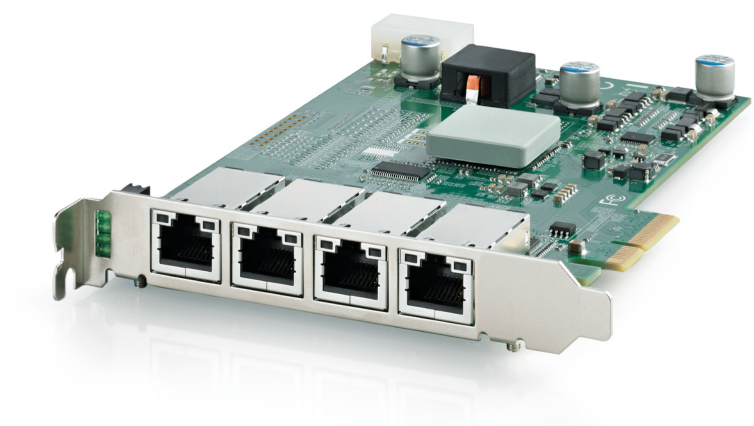
"My children loved the day care center from the very first day. They feel right at home. Knowing that lets me focus completely on my work."

Jörg Vogedes, dSPACE

Healthy, vegetarian food with ingredients from certified organic cultivation.

Ethernet Support for SCALEXIO

The new DS6331-PE Ethernet Board facilitates the extension of a dSPACE SCALEXIO® system by four additional Ethernet connections. The board offers four Ethernet ports, each of which supports the transfer modes 10BASE-T, 100BASE-T and 1000BASE-T. When you select these standard interfaces, each port can be used independently for a specific use case, either directly or by converting the signal via a suitable media converter. This concept offers easy access to the automotive interfaces 100BASE-T1 (1 Gbit/s BroadR-Reach) and 1000BASE-T1 (1 Gbit/s via an unshielded twisted single pair), and it is also future-proof and flexibly adaptable to new standards. The board supports various standards, such as IEEE 802.1AS (with hardware time stamp support), IEEE 802.1Qav (with hardware traffic shaping), and IEEE 1588 (with hardware time stamp support), which makes it most suitable for the automotive sector. The DS6331-PE Ethernet Board is inserted directly into the SCALEXIO Processing Unit and therefore offers a high-performance connection to the real-time PC. The configuration of the DS6331-PE Ethernet Board is fully software-controlled via ConfigurationDesk, the central configuration software for SCALEXIO. ■



New Safety Mechanisms for MicroAutoBox II

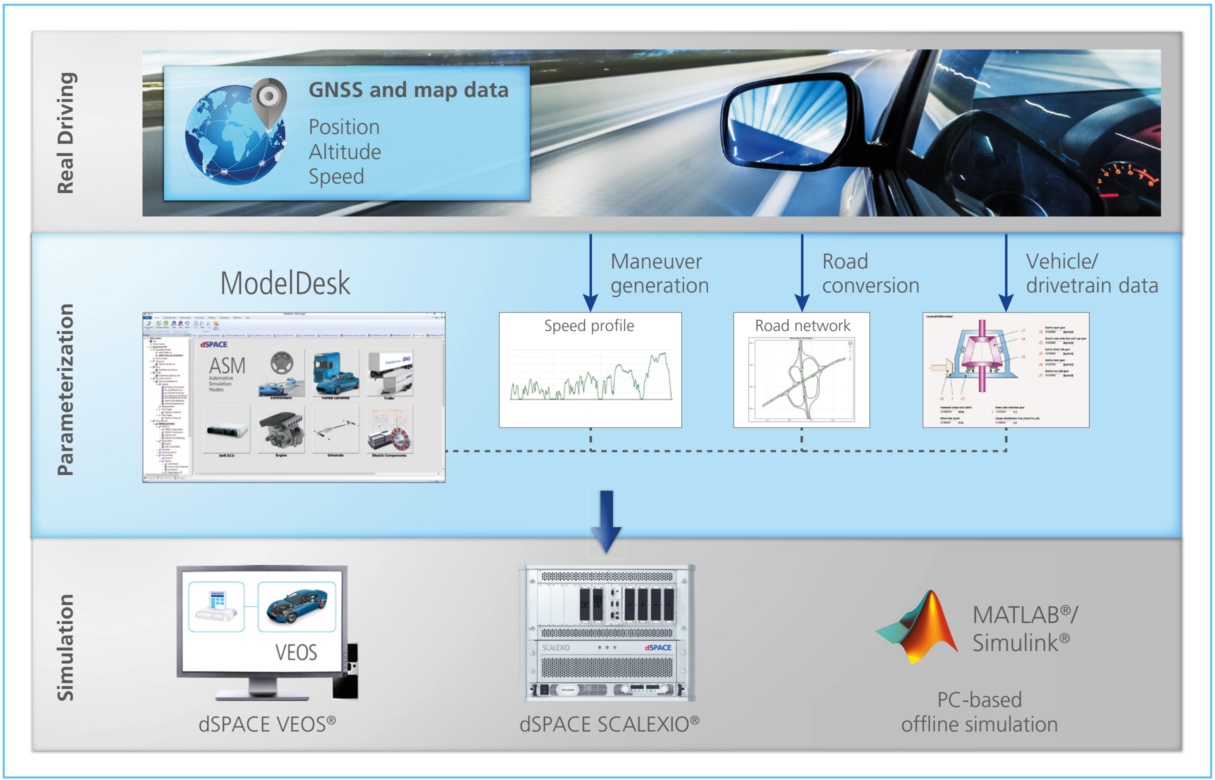
Safety-critical applications, e.g., for highly automated driving, require additional mechanisms that monitor the correct execution of control functions on an ECU. To reach a higher level of monitoring even in early function development phases, the prototyping system MicroAutoBox® II provides several monitoring functions that are common in series production. In the RTI Watchdog Blockset 2.0 (Release 2016-B), the multistage watchdog mechanism was already extended by an integrated challenge-response mechanism to monitor the correct execution of computations on the real-time processor. Version 2.1 of the blockset (Release 2017-A) now adds various memory integrity checks (heap, stack, and ROM monitoring). The checks make it possible to detect memory faults during start and run time of the real-time application, and the system can be set to a predefined state if an error occurs. Another new feature is supply voltage monitoring, which lets users monitor the supply voltage levels of MicroAutoBox II. This way, they can intervene before a critical supply voltage level is reached. ■

Virtual RDE Drives

New emission test procedures in the European Union require an exhaust emission evaluation under real driving conditions. Therefore, real driving emissions (RDE) tests complement conventional tests that are performed under laboratory conditions on chassis dynamometers.
Established simulation methods can be used to give automobile manufacturers insights into their vehicles' emission behavior under RDE test conditions even in early development phases. With the dSPACE Automotive Simulation Model (ASM) tool suite, RDE tests can be simulated virtually with different driving scenarios on rural roads, highways, and urban areas, and with complex surrounding traffic. The data captured during real test drives is used to make the simulations as realistic as possible. For this, the ASM tool suite supports the import of map data, such as Google Earth, OpenStreetMap, ADAS RP, OpenDrive as well as the import of satellite navigation data, such as GPS, GLONASS, BEIDOU, and Galileo. Altitudes, slopes, and lanes are also considered to simulate realistic maneuvers.
The vehicle dynamics and environment simulation can be executed together with an engine test bench to evaluate the actual emissions of the real combustion engine. If the engine is replaced with an engine model, an offline simulation provides first insights into the expected emission behavior on the basis of completely simulated components.
The virtual driving maneuvers and emission values can then be checked for compliance with legal regulations. To do this, evaluation routines, such as EMROAD of the Joint Research Centre of the European Commission and CLEAR of Graz University of Technology, can evaluate signals of the open Simulink models from the ASM tool suite. RDE tests that were defined this way can be reproduced with high precision and can be used to analyze different variants of vehicles, roads, and maneuvers by modifying the parameters. ■

More Information:

www.dspace.com/go/dMag_20171_RDEe



High Honor for dSPACE Endowed Professor

Professor Dr. Falko Dressler of the University of Paderborn has been named an IEEE Fellow (class of 2017). He is being recognized for contributions to adaptive and self-organizing communication protocols in sensor and vehicle networks. His work contributed to the literature with many fundamental theories and novel communication techniques for these networks. He identified the potential of self-organization techniques very early on and investigated these potentials first within the scope of sensor and actor networks. With his discoveries, he provided the foundations for a new generation of research into protocol design in massively distributed systems and large wireless networks. This work resulted in a ground-breaking model that can be applied to many problems in these areas but also to networks exhibiting a fast change of environmental conditions. dSPACE has endowed the professorship since 2014. dSPACE and the chair of Prof. Dressler are working together on various research projects, e.g., on traffic simulation.

Professor Dr. Falko Dressler, University of Paderborn

dSPACE Strengthens Its Presence in China

With the beginning of 2017, dSPACE has significantly strengthened its presence in the People´s Republic of China. The company has inaugurated an additional branch office in Beijing, which is set to provide dSPACE´s numerous customers in the capital and in the north of China with highly qualified local contact persons. On its overall floor space of almost 300 square meters, the new office also provides extensive laboratory space and highly sophisticated technical training facilities to reach the highest standards of customer support. Thus, the local dSPACE staff will be able to support current and prospective customers in all possible fields of business, from initial pre-sales product consultancy to extensive engineering services and general technical support. This will help dSPACE adapt to the needs of its steadily growing customer base. In Beijing and the north of China, customers include renowned companies and research institutions like BAIC, Brilliance, CATARC, CNR, Great Wall, Weichai, and many more.

Ribbon-cutting ceremony for the new dSPACE branch office in Beijing.

dSPACE on Board

Discover intriguing and innovative applications, achieved with dSPACE development tools

Efficiency with Torque Split Technology

Maruti Suzuki optimizes the parallel hybrid drive concepts of future hybrid vehicles. To do this, the developers implement a torque split controller that chooses all operating points of the combustion engine and electric motor in a way that ensures the most cost-effective energy and fuel consumption for all driving situations. With a MicroAutoBox II, the engineers test the controller in a real vehicle.

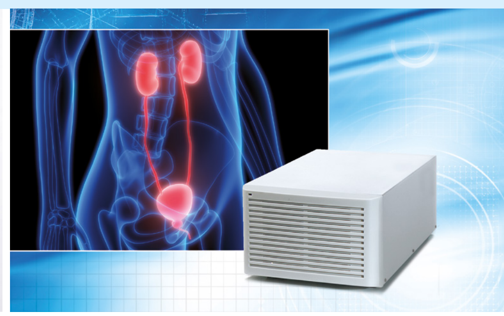
Improved hybrid technology by Maruti Suzuki, published in SAE Technical Paper 2015-26-0112. www.dspace.com/go/dMag_20171_Maruti

MicroAutoBox II and ControlDesk are used for in-vehicle testing.

Sensitive Control Wanted

Pressure measurements in the urethra are used to diagnose stress urinary incontinence. A team of researchers at the University of Tübingen significantly improved the efficiency of this method by developing a high-resolution, three-dimensional measurement on the basis of improved signal processing. A rapid control prototyping system from dSPACE evaluated all the sensors and controlled the actuators.

Stress urinary incontinence is a significant medical and social problem. www.dspace.com/go/dMag_20171_Biomed

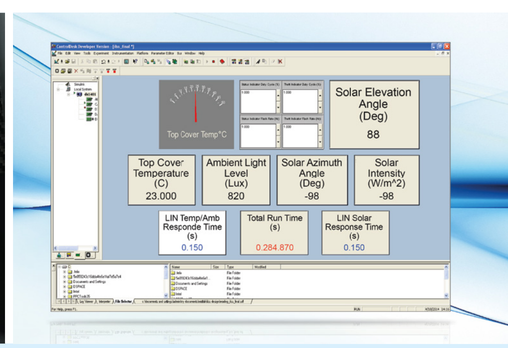


Sensitive actuators and high-resolution, three-dimensional measurement, controlled by a dSPACE rapid control prototyping system.

Setting up a Development Environment

To develop electronic control units (ECUs) for air conditioners at General Motors, Michigan State University created powerful software libraries. The libraries were used for the bus communication between the environment sensors, ECU and actuators on the basis of MicroAutoBox and ControlDesk. The libraries are designed in a way that they can be reused for different kinds of projects.

The air conditioning controls in the Corvette Stingray from General Motors. www.dspace.com/go/dMag_20171_UniMic



During function development, ControlDesk visualizes the signals of important sensors.

Learn more about these applications online, via videos, photos, and reports: www.dspace.com/go/dMag_20171_REF_E